POWER PLANT ENGINEERING

Established Over 31 Years

VOL. XXXI CHICAGO, AUGUST 15, 1927 No. 16

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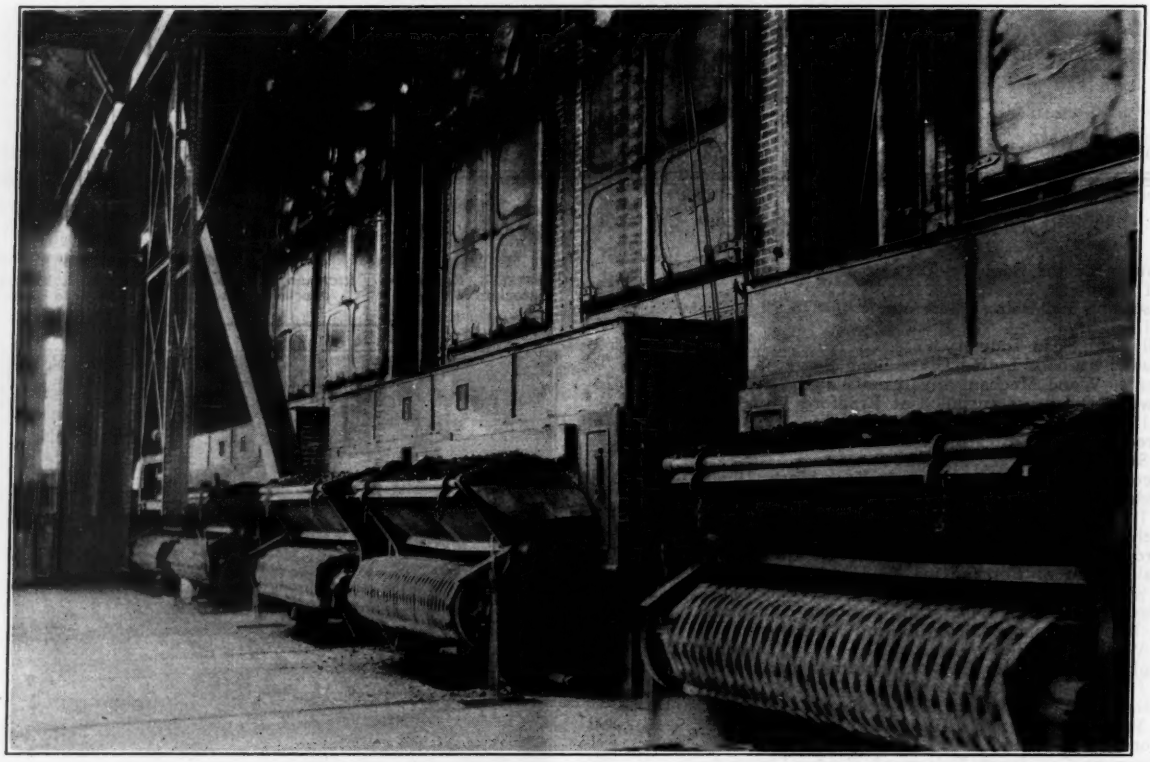
Far Be It From Us

—to criticize our advertising department, but it does seem that they are not up on their toes. We have looked through many back issues trying to locate the manufacturer of the contrivance shown above. We find pumps, boiler feed, centrifugal, deep well, electric, elevator, fire, general service, hydraulic pressure, jet, oil, power, rotary, steam, turbine, vacuum and waterworks. Nowhere, however, is there a mention of pumps; burro, or as our Mexican friend who owns the pump would probably say, "bomba da vaca" or "bomba de burro" depending upon whether his estate boasted a cow or burro which could be converted into a prime mover.

We understand this is marked "Pat. by Marco Polo," on the rim of the cog wheel. Unscrupulous manufacturers should note this for although we do not know who owns and manufactures these "chain-of-pots" they probably have a wide-awake patent attorney even though their advertising man is asleep. The unlubricated bearings are an important feature—they furnish the squeak. When the squeak stops the engineer knows its time to get up out of the shade and beat the mule.

Now the negligence on the part of our advertising men is no doubt the reason why the engineers at Kansas City overlooked this new equipment and installed 400-hp. motor-driven centrifugal pumps instead of a series of the new modern hay burners which our special Mexican under cover agent J. J. McDougall unearthed. However, if engineers in this country will insist on following a non-progressive policy we can follow the newspaper policy of giving you what you want rather than what's good for you.



Power for the Sanitary District of Indianapolis

ELECTRIC POWER, PROCESS STEAM AND COMPRESSED AIR FOR NEW GARBAGE DISPOSAL AND SEWAGE DISPOSAL PLANTS FURNISHED BY MODERN POWER PLANT BURNING INDIANA SCREENINGS

PROPER AND EFFICIENT handling of sewage and garbage in a large city is a matter of major importance and the development and progress of power plant engineering in recent years has done much to help the sanitary engineer solve these problems.

In Indiana, the city of Indianapolis and the town of Woodruff constitute the Sanitary District of Indianapolis and this district, under the control of a board of sanitary commissioners, has recently completed and put into service new sewage disposal and garbage reduction plants. Sewage from the entire district is received, screened through fine revolving screens to eliminate the larger particles and sent through continuous settling basins where the heavy particles sink to the bottom and are raked to one end by means of a drag scraper. The screened and settled sewage is then lifted about 20 ft. by centrifugal pumps to the treatment plant to be mixed with a considerable volume of biologically active sludge before passing through a series of tanks and thoroughly agitated by means of air. In this manner the

FIG. 1. COMPRESSED AIR FOR THE ACTIVATED SLUDGE PROCESS IS FURNISHED BY THREE TURBO BLOWERS

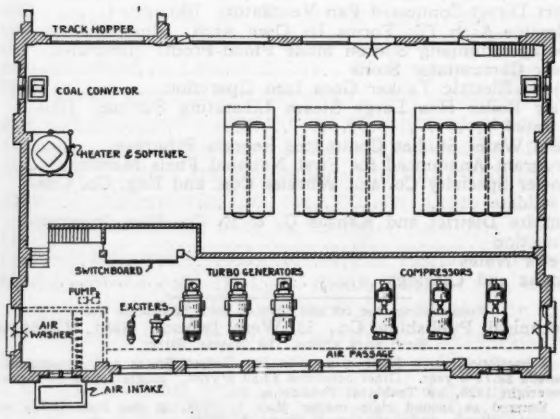


FIG. 2. PLAN OF THE POWER HOUSE WITH THE AIR WASHER IN THE BASEMENT SHOWN BY DOTTED LINE

bacterial growth is promoted and the organic matter in the sewage oxidized. It is estimated that each particle travels a total distance of 7 miles in these tanks which measure 20 ft. wide by 15 ft. deep and 236 yd. long. Air is admitted through diffuser plates in the bottom of the tank designed so as to give the maximum agitation and maximum travel of the sewage particles.

Garbage is received by wagon and after picking out the tin cans and non-combustible matter, is carried by conveyors to cookers, where it is cooked several hours by steam for the purpose of extracting grease. The cooked garbage is then processed and converted into stock food which is readily disposed of at a good price. This with the hide and grease sales is a considerable source of revenue and makes the garbage disposal plant practically self-supporting. The garbage disposal plant was designed by E. W. McCullough, consulting engineer.

Power for both plants is supplied by a common power house, which was designed by Charles H. Hurd, consulting engineer of the sewage disposal plant. Steam is generated at 225 lb. gage and 100 deg. F. superheat in 5 Babcock & Wilcox Co. longitudinal drum boilers and is distributed to various machines in the power house and for process work in the garbage disposal plant.

Indiana screenings are fired on Greene natural draft chain grate stokers. All boilers are connected by means of a breeching to a single radial brick stack 200 ft. high and 9 ft. in diameter. Coal is received in hopper bottom cars, dumped into a track hopper, crushed and then elevated to a 600-t. overhead bunker. From the bunker it is distributed to the stoker hoppers by means of a Link-Belt weigh larry. Ash is raked from ash hoppers into industrial cars which are pushed to the west end of the basement, elevated in a steam operated service elevator and by means of gasoline locomotives distributed to various parts of the grounds to be used for filling purposes.

Three Turbo-Generators Furnish Electric Power

Electric power is generated at 440 v., 3-phase, 60-cycle by two 500-kw. and one 750-kw. General Electric turbo-generators. Excitation is furnished by two 125-v. exciters, one turbine driven and the other a motor-driven unit. Three DeLaval turbine driven centrifugal blowers furnish air at a pressure of 8.5 to 10 lb. for the aeration tank. The turbines are rated at 701 hp. at 3600 r.p.m. or 1080 hp. at 3740 r.p.m. and the air delivery of each machine can be varied from a minimum of 12,000 cu. ft. of free air per min. at 8.5 lb. to a maximum of 24,000 cu. ft. of free air per min. at 10 lb. Between 40 and 41 million cu. ft. of free air per day is supplied and this air is measured by a Republic indicating, recording and integrating flow meter. The meter element, consisting of an orifice, 27.2 in. in diameter, is installed in a 42-in. inside diameter air main just as it leaves the power house and the meter is calibrated to measure air at 7.5 lb. pressure and 180 deg. F.

Each turbine, both on the blowers and generators, is supplied with an individual oil cooler and oil pump. In addition to this, a DeLaval No. 601 centrifugal oil purifier is installed and the oil from one turbine cleaned each week. Oil from the various units runs through a

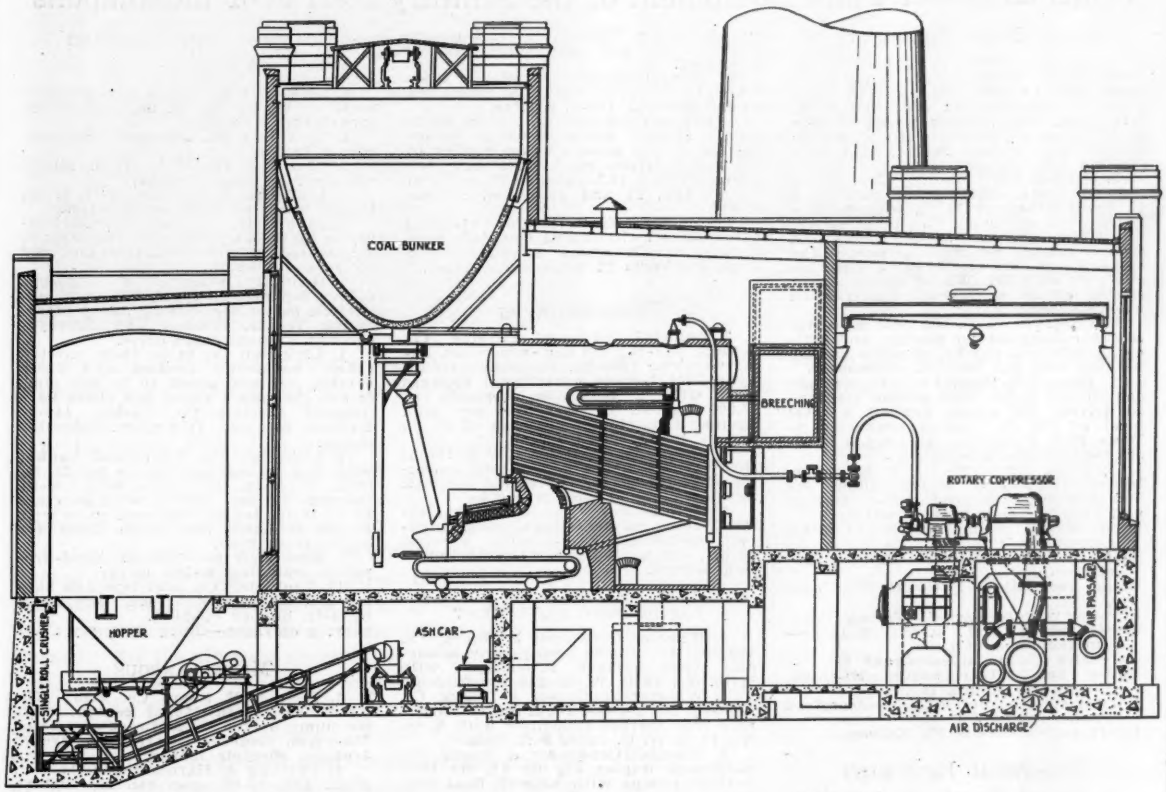


FIG. 3. A CROSS-SECTION OF THE PLANT SHOWS THE ARRANGEMENT OF THE EQUIPMENT

purifier by gravity and is pumped back by two American steam pumps connected up to supply any one of the units. The two 500-kw. turbines and the three blower turbines exhaust to Wheeler Condenser & Engineering Co. rectangular admiralty type surface condensers, each with a condensing surface of 1000 sq. ft.

Each condenser is supplied with a 5¼ by 4¾ by 5-in. horizontal duplex wet vacuum pump with a hotwell float control and with a two-stage steam ejector with surface inter and after coolers. When supplied with 1200 g.p.m. of 55 deg. F. condensing water, the condensers are guaranteed to maintain a vacuum of 28.69, 28.54 and 28.39 in. of vacuum, when condensing 9000, 10,000 and 11,000 lb. of steam per hour respectively. If 70 deg. water is used, the corresponding vacuums are 27.94, 27.69 and 27.49. Under the 750-kw. turbine a 1400-sq. ft. condenser of the same type has been installed. This is equipped with the same auxiliaries.

At the present time circulating water is supplied from wells at a temperature of about 54 deg. F. although experiments carried on using clarified sewage for circulating water, have been satisfactory. Because of the increased load, additional provision had to be made for circulating water, and it was important to solve this problem at the earliest possible time with the minimum expense. Circulating water passes through the condenser and from there goes to Eagle Creek. Formerly well water was used in all condensers, but when the piping changes now under way are completed, clarified sewage will be used on about half of them.

Well water and circulating pumps are located in a screen house some 200 or 300 yd. from the power house. Boiler feed water and service water necessary for the operation of the power plant are taken from the discharge side of the condenser. The feed water is then treated in a Cochrane hot process treater designed for heating and softening 6000 gal. per hr. of make-up water and to heat without softening 6000 gal. per hr. of condensate. The make-up water and condensate are heated in separate compartments of the heater located above the treater as shown in Fig. 6. The condensate goes directly from the heating compartment to the boiler feed pump without passing through the sedimentation tanks and filter. Make-up water is treated with chemicals automatically proportioned in accordance with the flow of water. From the sedimentation tank, the water passes through a filter which removes the last trace of suspended matter. A typical analysis for well water as used for make-up is shown in the table.

Boiler feed water is pumped to the boilers by two

Principal Power Plant Equipment of the Sanitary District of Indianapolis

Boiler Room Equipment

5. Babcock & Wilcox 400-hp., 225-lb. longitudinal drum boilers with 18-ft. tubes built 14 tubes high and 14 tubes wide. 2. drums 42 in. wide and 20 ft. 4 in. long. Each boiler equipped with B. & W. superheaters to give 100-deg. superheat at normal rating, fired with Indiana screenings.

5. Combustion Engrg. Co. Green natural draft chain grate stokers, 7 ft. 6 in. wide and 11 ft. long with a grate area of 80 sq. ft. Each stoker has Green pressure water backs and Green radial Sealflex arches. The stokers are driven from a common shaft by an E. H. Wachs steam stoker engine or by a General Electric Co. variable speed motor.

1. Cochrane Corp. hot process water softener designed for heating and softening 6000 gal. per hr. of make-up and heating 6000 gal. per hr. condensate.

2. Dean Hill Pump Co. 2-in., 4-stage centrifugal boiler feed pumps designed to deliver 160 g.p.m. against a total head of 580 ft. Direct connected to Dean Hill Pump Co. 2225-r.p.m. non-condensing steam turbines.

1. Dean Bros. 10 by 7 by 12-in. horizontal Duplex steam pump for emergency boiler feed, boiler testing and high pressure service water.

Feed water regulators—Northern Equipment Co.
Soot blowers—Diamond Power Specialty Co.
Boiler regulators—National Regulator Co.
Blowoff valves—Yarnall-Waring Co.
Steel valves and steam headers—Lunkenheimer Co.
Gate and globe valves—Crane Co.
Boiler and safety valves—Manning, Maxwell & Moore, Inc.
Forged steel header fittings—American Power Piping Co.
Draft gages—Lewis M. Ellison.

Electrical Equipment

2. General Electric Co. 3600-r.p.m., 200-lb., 100-deg. superheat, 28-in. vacuum, 5-stage turbines driving 500-kw., 480-v., 3-phase, 60-cycle, 80 per cent-power factor generators.

1. General Electric Co. 3600-r.p.m., 200-lb., 100 deg.-superheat, 28-in. turbine driving a 750-kw., 480-v., 3-phase, 60-cycle, 80 per cent-power factor generator.

1. General Electric Co. 30-hp., 1800-r.p.m., 440-v. motor driving a compound wound Form A 120-v. exciter.

1. General Electric Co. 125-v., 3600-r.p.m., 25-kw. non-condensing turbo-exciter of the same characteristics of the motor-driven machine, steam consumption 63.8, 48.3 and 45.5 lb. per kw-hr. at 12.5, 25 and 31.25 kw. respectively.

1. General Electric Co. 11-panel black slate switchboard complete with meters, synchronizing equipmens and Type CA Form 22 voltage regulator.

Turbo-Blowers

3. DeLaval Steam Turbine Co. 4-stage, 225-lb., 100 deg.-superheat, 28-in. vacuum, 1200-hp. turbines driving Type NE4 3-stage centrifugal blowers each with a maximum capacity of 24,000 cu. ft. of free air per min. against a maximum pressure of 10 lb. per sq. in. at 4000 r.p.m.

3. Spray Engineering Co. sectional spray type washers with a total capacity of 80,000 cu. ft. of free air per min. Nozzles supplied with water by

2. Buffalo Forge Co. 400-g.p.m., 80-ft., 1750-r.p.m. centrifugal pumps, direct connected to General Electric 15-hp., 440-v., 3-phase, 60-cycle induction motors.

Condensing Equipment

5. Wheeler Condenser & Engrg. Co. 1000-sq. ft., 2-pass rectangular admiralty type surface condensers with ¾-in. No. 18 B. W. G. tubes 9 ft. long.

1. Wheeler Condenser & Engrg. Co. 1400-sq. ft., 2-pass, rectangular admiralty type surface condenser with ¾-in. No. 18 B. W. G. tubes 9 ft. long.

6. Wheeler Condenser & Engrg. Co. horizontal duplex 5¼ by 4¾ by 5-in. hotwell pumps with hotwell float control.

6. Wheeler Condenser & Engrg. Co. 2-stage steam ejectors with surface intercoolers. Ejectors rated at 250 lb. of steam per hr.

Water sealed atmospheric relief valves—Wheeler Condenser & Engrg. Co.

Coal and Ash Handling Equipment

1. Link-Belt Co. steel bar grizzley made of 1½ by 3¼-in. bars spaced to give 12-in. openings.

1. Link-Belt Co. automatic reciprocating feeder.

1. Link-Belt Co. 30 by 24-in. single roll spring release crusher.

1. Link-Belt Co. 18 by 24-ft. track hopper made of ¼-in. steel plate.

1. Link-Belt Co. 24-in. apron conveyor 34 ft. long made of overlapping corrugated pans of ¼-in. steel mounted on 9-in. rollers.

1. General Electric Co. 25-hp., 440-v., 3-phase, 60-cycle, 870-r.p.m. induction motor for driving the reciprocating feeder, crusher and conveyor through a silent chain drive.

1. Link-Belt Co. 24 by 18-in. carrier, 113-ft. horizontal centers and 52-ft. vertical centers, speed 40 ft. per min., driven through a silent belt chain by a General Electric Co. 7.5-hp., 440-v., 3-phase, 60-cycle, 1150-r.p.m. induction motor.

1. Link-Belt Co. 600-t. coal bunker with top measurements 114 by 22 ft., made of ⅛-in. steel plate with 2½-in. concrete lining. Fitted with fourteen 16 by 16-in. duplex undercut gates with levers to open and close from the boiler room floor.

1. Link-Belt Co. 1500-lb. hand-propelled traveling weigh larry.

12. Link-Belt Co. cast-iron ash hopper gates, 2 gates fit into one 24-in. by 6-ft. hopper opening.

Service elevator—Craig Ridgway Co.

Miscellaneous

1. Dean Hill Pump Co. 3-in., 250-g.p.m., 60-lb. centrifugal general service pump driven by a direct connected 750-r.p.m. General Electric Co. 440-v., 3-phase, 60-cycle motor.

1. Pawling & Harnishfeger Co. 5-t., 25-ft. lift, 23-ft. span electric turbine room crane.

Air flow meter—Republic Flow Meters Co.
Boiler feed meter—Bailey Meter Co.
Centrifugal oil purifier—DeLaval Separator Co.
Oil pumps—American Steam Pump Co.

FIG. 4. STEAM IS SUPPLIED TO ALL THE MACHINES FROM A HEADER RUNNING THE LENGTH OF THE TURBINE ROOM

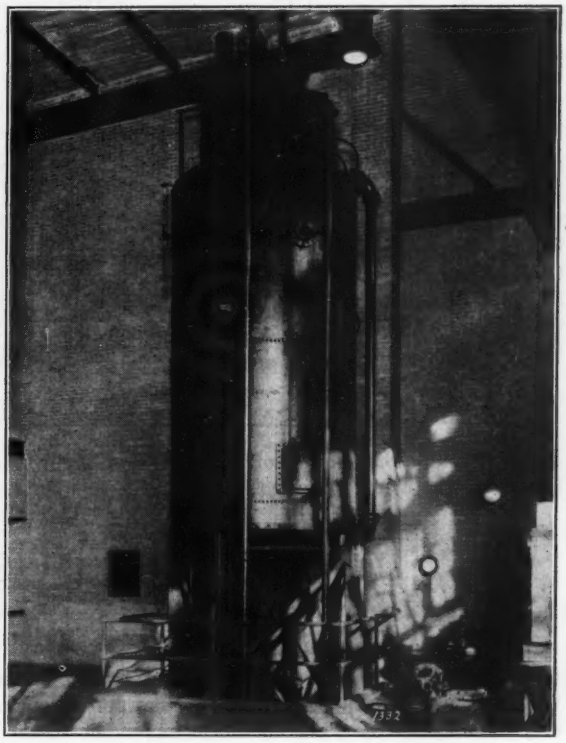


FIG. 6. A HOT PROCESS SOFTENER WITH THE HEATER ON TOP IS USED FOR TREATING AND HEATING THE FEED WATER

3-in., four-stage Dean Hill Pump Co. centrifugal boiler feed pumps driven by non-condensing steam turbines. Each pump is rated at 160 g.p.m. against 580 ft. head when operating at 2500 r.p.m. For emergency boiler feed testing and other high pressure service water around the boiler room, a Dean Bros. 10 by 7 by 12-in. horizontal duplex steam pump is so piped up that it will take the condensate direct when the heater is being cleaned. All the air used or supplied by the blowers is washed with a Spray Engineering Co. special washer made up in three sections having a total capacity of 80,000 cu. ft. of air per min. Water for the sprays is furnished by two Buffalo centrifugal pumps designed to deliver 400 g.p.m. against a total head of 80 ft. Each of these pumps is driven by a 15-hp., 440-v.

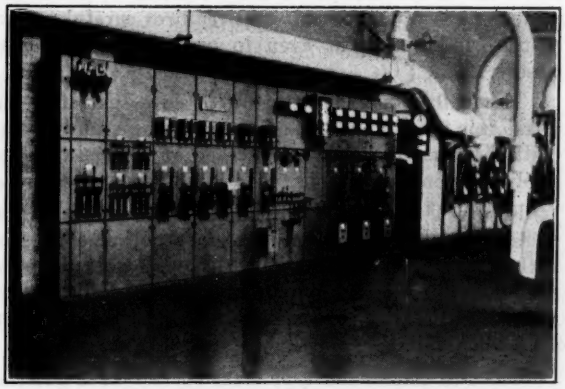


FIG. 5. AN 11-PANEL BLACK SLATE SWITCHBOARD TAKES CARE OF THE ELECTRICAL DISTRIBUTION

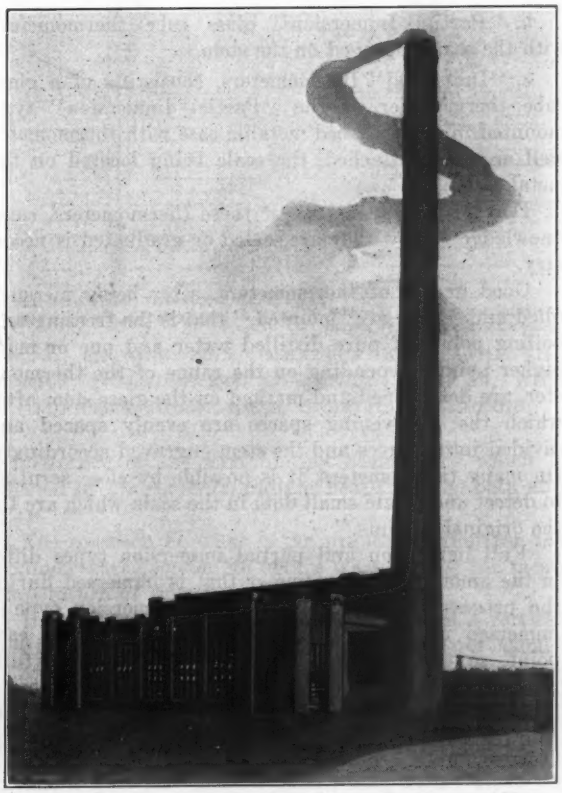


FIG. 7. THE ARCHITECTURAL TREATMENT OF THE BUILDING IS EXCELLENT

3-phase, 60-cycle General Electric motor at 1750 r.p.m. Water used by the sprays is treated by chemicals introduced through the suction of a centrifugal pump; before this treatment was used, considerable trouble was occasioned by scale forming on the spray nozzles. Condensate is used for make-up water for the washer.

WELL WATER IS USED RAW IN THE CONDENSERS AND TREATED FOR BOILER FEED MAKE-UP

Solids	Gr. per U. S. Gal.
Organic and volatile	3.20
Silica	.17
Iron oxide alumina	.06
Calcium carbonate	9.03
Calcium sulphate	3.38
Calcium carbonate	5.60
Sodium sulphate	1.24
Sodium chloride	2.10
Total solids	24.78

The three-stage compressors are of the single suction type with chrome nickel steel enclosed wheels. Automatic balance is provided by means of a balancing disk operating in connection with the last pressure wheel. The turbines driving them are of the four-stage type, each stage consisting of one wheel upon which two rows of buckets are mounted. The governor valve is operated directly from the governor head and is arranged so that the speed of the turbine can be varied by means of an adjustable spring in order to govern the capacity of the blower to meet the requirements of the activated sludge plant.

The building itself is of brick construction and its architectural treatment is such that it stands out prominently and might well be taken as a model for many other plants of the industrial or small central station type.

Installing and Using Thermometers†

METHOD OF CORRECTING FULL IMMERSION AND PARTIAL IMMERSION TYPES, CONSTRUCTION OF WELLS, METHODS OF CHECKING. BY S. A. CURRY*

SPACE WILL NOT permit of a complete and thorough treatment of thermometers and thermometry so only three types of thermometers or methods of measuring temperatures, will be considered, these being the most generally used:

a. "Full Immersion" glass tube thermometers with the scale engraved on the stem.

b. "Partial Immersion" glass tube thermometers with the scale engraved on the stem.

c. "Industrial" thermometers, consisting of a glass tube thermometer of the "Partial Immersion" type mounted in a glass-faced metallic case with thermometer well or socket attached, the scale being located on the metal case.

For the intelligent use of these thermometers, some knowledge of how they are scaled or graduated is necessary.

Good grades of thermometers, after being mercury filled and sealed, are "pointed," that is the freezing and boiling points of pure distilled water and one or more higher points, depending on the range of the thermometer, are determined and marked on the glass stem after which the intervening spaces are evenly spaced and divided into degrees and the stem engraved accordingly. On many thermometers, it is possible by close scrutiny to detect and locate small dots in the scale which are the the original "points."

Full immersion and partial immersion types differ in the amount of thermometer that is immersed during the process of pointing. The full immersion type is immersed in a bath of uniform temperature for each point, so that the entire thread of mercury is fully immersed to the "point" to be registered. The partial immersion type is immersed for *all* "points" in a bath to a fixed line, marked and engraved on the stem (generally 3 in. up from the bulb) and the bath is brought to each temperature to be pointed, allowing the thread of mercury to rise in the stem beyond the point of immersion. The portion of the stem containing the emergency mercury is kept in atmosphere of a constant temperature, usually 70 deg. F.

To obtain correct indications, therefore, it is necessary to use thermometers with conditions the same as during the process of pointing. Full immersion thermometers must be immersed at least to the top of the thread of mercury registering the temperature and partial immersion thermometers immersed to the immersion line (neither above nor below) and the atmospheric temperature around the emergent stem be at the same temperature as during pointing.

Often it is not practically possible to comply with these requirements and to duplicate the conditions during pointing, so it is necessary to determine and apply stem corrections. Failure to make accurate stem corrections will cause serious errors amounting in some cases with high temperatures to as much as 30 deg. or more. Accurate determination of the variation from normal conditions is often difficult and requires careful consideration and judgment even to approach them at all closely.

The full immersion type with less than full immersion is the simplest case for correcting and for illustrating the most convenient method of determining and applying stem corrections.

Figure 1 illustrates full immersion and partial immersion type thermometers improperly immersed and with auxiliary thermometers attached to measure what should be the average stem temperature of the portion of the stem that is subjected to a temperature different from that during pointing.

The full immersion type stem correction is obtained with the following formula: $K = 0.000088\ N\ (T - t)$, where

*South Philadelphia Works, Westinghouse Elec. & Mfg. Co.

†This is one of a series of articles by Mr. Curry on the more common forms of power house instruments. An article on pressure gages appeared in the May 15, 1927 issue and one on manometers and U-tubes in the June 1, 1927 issue.

K = number of degrees to be added to the observed temperature when T is greater than t or subtracted when T is less than t.
N = number of degrees of mercury column emergence.
T = the temperature indicated by the thermometer.
t = the mean temperature of the portion of the stem containing the emergent column of mercury.

Assume a full immersion thermometer, immersed to the 100 deg. mark, reading a temperature T = 500 deg. Assume the auxiliary thermometer indicates the average temperature t of the emergent mercury column as 130 deg. Then, substituting these values in the formula, we have:

K = 0.000088 × 400 (500 — 130) = 13 deg. to be added to the observed temperature T, giving 513 deg. as the corrected temperature.

A further refinement in calculation is obtainable by substituting T plus K as found for T and recalculating.

Then K = 0.000088 × 400 (513 — 130) = 13.5, deg. making the corrected temperature 513.5 deg.

This formula, as can readily be seen, involves the multiplication of the number of degrees of the thread of mercury that is at an improper temperature during service by the difference of temperatures during service and pointing, by the constant 0.000088. This constant represents the relative expansion of the stem glass on which the scale is engraved and of the mercury. For different grades of glass this constant would change slightly but the difference would be very slight and negligible for most cases.

For partial immersion thermometers the formula, modified in accordance with the preceding paragraph, is applicable. With this type of thermometer there are usually two portions of the mercury column that are subjected to a different temperature in service from that during pointing; that is, it may be immersed to a point above or below the immersion line, and the atmospheric temperature around the emergent stem may be more or less than when pointing, consequently it is necessary to determine and apply two stem corrections.

Take a case as illustrated in Fig. 1, showing the partial immersion thermometer with the immersion line at the 0 deg. of the scale, immersed to the 100 deg. point. The main thermometer registers 500 deg. and the auxiliary thermometer attached registers 130 deg. as the mean temperature of the emergent portion of the stem.

For the over immersion the correction would be for 100 deg. of stem above the immersion line being subjected to a temperature of 500 deg. instead of 70 deg. as during pointing and then from the formula:

K = 0.000088 × 100 (500 — 70) = 3.8 deg. to be subtracted from the temperature indication of the thermometer.

For the emergent portion of the stem 500 deg. — 100 deg. or 400 deg., which is shown by auxiliary thermometer to be at a mean temperature of 130 deg. instead of 70 deg. Then from the formula:

K = 0.000088 (500 — 100) (130 — 70) = 2.1 deg. to be subtracted from the temperature indicated by the thermometer. The corrected temperature would be 500 deg. — 3.8 deg. — 2.1 deg. or 494.1 deg.

With insufficiently immersed partial immersion thermometers it is necessary to use two auxiliary thermometers, one for the portion of the stem below the immersion line not immersed and the other for the mean temperature of the stem above the immersion line. The location and the attachment of the auxiliary thermometers require careful attention in order to get dependable results.

Take the case of the full immersion thermometer partially immersed in a hot bath. We are trying to determine the mean temperature of the portion of the glass stem containing the emergent portion of the mercury column. The lower portion of the stem immersed in the hot bath is at a much higher temperature than the emergent portion. As glass is a poor heat conductor, only a small portion of the emergent stem adjacent to the immersed portion is heated by heat conduction, the balance of the emergent stem being subjected to the

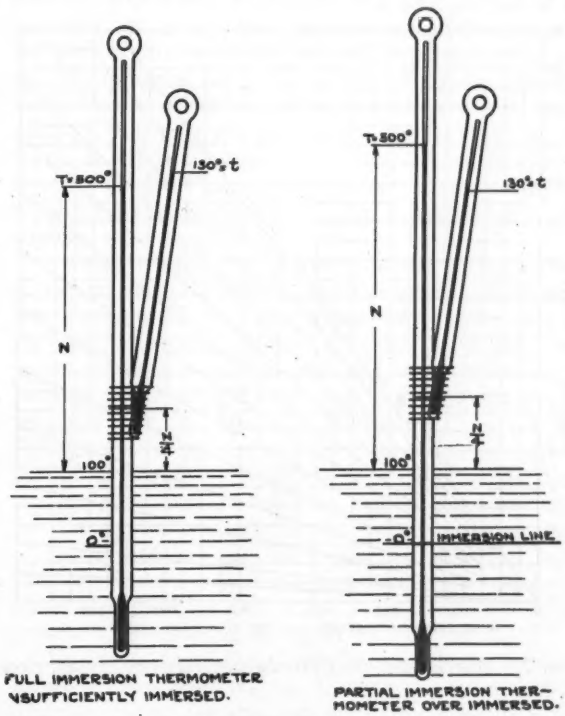


FIG. 1. SHOWING FULL IMMERSION AND PARTIAL IMMERSION THERMOMETERS IMPROPERLY IMMERSED, WITH AUXILIARY THERMOMETER TO OBTAIN CORRECTION

temperature of the surrounding atmosphere which is affected by air currents, radiant heat from the bath and so on.

The question is, what is the proper location for the auxiliary thermometer, to obtain what will be the mean temperature of the emergent stem?

Usually, with the main thermometer set in a vertical position, the bulb of the auxiliary thermometer should be attached and held in close contact with the stem of the main thermometer at a point from ¼ to 1/3 the length of the emergent steam up from the upper limit of immersion.

It will be noted that the auxiliary thermometer, regardless of whether the full or partial immersion types are used, will not have proper immersion; usually only the bulb held in contact with the main thermometer

stem is subjected to the same temperature as the stem of the main thermometer. This, however, is not likely to cause serious error except in extremely bad cases. For instance, in the total immersion problem worked out, an auxiliary thermometer error of 10 deg. would affect the formula results about 0.35 of one degree.

Encasing both the main and auxiliary thermometers in a ¾-in. or 1-in. glass tube produces desirable conditions that enable the stem correction to be determined with reasonable assurance of accuracy. Both thermometers should be read through the glass tube as it should not be disturbed. This arrangement provides protection from changes and variations in the atmospheric temperatures, drafts, etc. Furthermore, because of the radiant heat from the bath or thermometer well and a more or less constant air condition (provided the bottom of the glass case rests in the bath or on top of the thermometer well, keeping the lower end sealed), the emergent stem is maintained at a higher and more uniform temperature than when not so protected. This insures better measurable conditions and when full immersion thermometers are used, for both main and auxiliary, gives truer conditions for the auxiliary and, on account of the higher temperature of the emergent stem of the main thermometer, reduces the amount of correction.

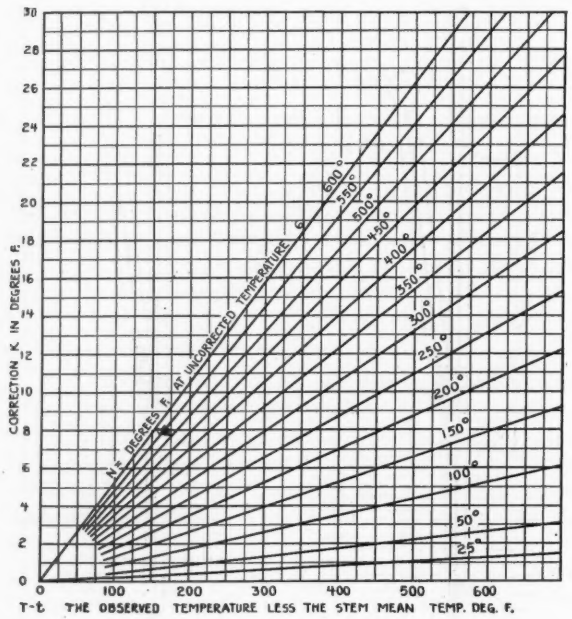


FIG. 2. CURVES SHOWING THERMOMETER STEM CORRECTION

Figure 2 shows curves based on the foregoing stem correction formulas giving stem corrections in degrees Fahrenheit applicable to both full and partial immersion type thermometers.

Thermometer Wells

Thermometers of the types under consideration are used either by inserting them directly in the medium to be measured, as in a tank of water, or indirectly through the use of thermometer wells extending into the medium to be measured, as in the case of steam or water flowing through pipes, the well being filled with some good heat conducting liquid in which the thermometer is inserted. Wells must receive careful consideration both as to design and location.

Following are some suggestions for construction of thermometer wells:

1. Make the bore of suitable diameter but no larger than is necessary for the comfortable insertion and removal of thermometer and maintenance of liquid bath.
2. Material to be of good heat transfer qualities and suitable for use in the medium to be measured.
3. Make the walls as thin as possible, care being taken to make them strong enough to withstand safely high pressures when so used.
4. For use with high temperatures, as with superheated steam, or with varying temperatures, the finned type of well should be used.
5. Avoid making the following parts of the well any larger than is necessary: the threaded portion for attachment, the size of the hex. and the extension outside of wall of vessel or pipe. This is to reduce the radiation losses.
6. Make wells long enough to extend far enough into the medium to be measured to get representative temperatures, keeping in mind that for gases or liquids flowing through pipes or contained in vessels, it is possible to have currents or strata of different temperatures. Uncovered or imperfectly insulated walls of pipes or vessels containing the medium may, by heat radiation, change the temperature of the adjacent medium or, by heat conduction either to or from the well, may affect the thermometer indications.
7. The well should be filled with some suitable liquid with good heat transfer qualities for the uniform conduction of heat from well to thermometer. Mercury is very good and suitable for temperatures up to say 550 deg. F. At about 500 deg. and above evaporation exists and it is necessary to keep replenished. Tin and solder serves best for temperatures from 550 deg. to 750 deg. F. Oils may be used for the lower temperatures. Empty wells should never be used, as air is a poor heat conductor and the portions of the thermometer not in direct contact with the metallic parts of the well will probably be at different temperatures from the other portions.

Thermometers should always be read in place without withdrawal from the immersion as, under certain conditions, changes which quickly take place will seriously and erroneously affect the reading.

Full immersion thermometers may be immersed beyond the end of the mercury column and be withdrawn to the top of the mercury column to permit reading without affecting their indication provided the medium in which the thermometer is inserted is of a uniform temperature.

Checking of Thermometers

Thermometers must be properly checked to know that they are not giving incorrect indications. There are several methods of checking glass tube thermometers, all of which require the most careful consideration and handling to get correct results.

1. Have thermometer checked by the U. S. Bureau of Standards at Washington, D. C., where they have adequate equipment and give authentic results.
2. Comparison with other thermometers of known accuracy. This requires suitable equipment so as to

have both thermometers submitted to the same temperatures and to know that all conditions are suitable for each individual thermometer.

3. Checking the boiling point of distilled water and the melting points of ice and other materials such as tin, lead and zinc, plotting curves from such points and assuming that the intermediate graduations vary in accordance with the curve. This is not necessarily true as the spacing of the divisions on the thermometer stem may not be exactly uniform. This method requires special equipment and knowledge that the various metals are pure. The atmospheric pressure must be taken into consideration and the thermometer readings compared with the known boiling or melting temperatures of the materials used.

4. Checking against the known temperatures of *saturated* steam at different pressures. It is necessary to know that *saturated* steam, free from air admixture, and not superheated steam is being used, to know positively that accurate and true steam pressures are being obtained, and that no errors are being introduced by the use of thermometer wells, pipe radiation and the like.

It is not dependable, after having a thermometer once checked, say at the U. S. Bureau of Standards, to use such calibrations indefinitely without having some of the major points checked from time to time, as they are subject to changes.

The glass goes through an aging process, particularly when used with high temperatures, producing changes in the length of scale and of the volumetric content of the bulb, the walls of which are quite thin; air leaks to the upper part of the stem may exist even though extremely small, mercury becomes separated, and all of these produce errors.

Industrial Thermometers

The industrial type of thermometer is intended for permanent installation and for general observation purposes where close accuracy is not required.

Careful consideration should be given to attachment and location. Make sure the metallic bulb is clean and fits tight in the socket so as to get good heat conduction, and that the socket has proper immersion in the medium being measured. Cases have been experienced of serious errors existing in measuring the temperatures of the return oil from turbine bearings on account of the oil pipe being only partially filled with oil and the thermometer socket not extending into the oil.

Undue heating of the metallic case containing the scale is likely to cause distortion of the scale by expansion. The industrial type should be checked under its working conditions with a good glass tube thermometer of known accuracy.

More than 13,600 mi. of earth roads included in the State highway systems of the 48 states were surfaced by the several highway departments in 1926, according to information compiled from State reports by the Bureau of Public Roads of the United States Department of Agriculture. The total length of surfaced roads constructed by State agencies during the year was 19,492 mi., of which 13,664 mi. were laid over former earth roads and 5828 mi. represented a rebuilding of old surfaces.

Oil Engines in Industry

In a paper on the above topic delivered by J. W. Chadwick of the Ingersoll-Rand Co. at the Oil Power Week Meeting of the N. A. S. E. in Chicago, on April 16, the following interesting facts were brought out.

We sometimes read of fuel economies in European practice which appear to be better than those in this country. A careful analysis of these statements will show that reports of European engines are frequently based on oil consumption per indicated horsepower and not on brake horsepower, which if corrected down to the latter, after deducting the power required to operate injection compressors, cylinder charging compressors, etc., will show that our economies match those of Europe.

Referring to the great use of oil engines in the pipe line industry where continuous full load service is required 24 hr. a day, Mr. Chadwick stated that over 30 per cent of all the oil engines built to date were in use by oil companies for pumping oil. In many installations, because of the greater value of the crude oil being pumped, this oil is not used in the engines, but fuel oil, which is crude oil from which the lighter and more valuable products have been removed, is shipped to the pumping stations in tank cars for consumption in the engines.

Twenty-five per cent of the oil engines in use outside of the marine field are in central stations. Refrigeration plants use 5 per cent; mines and quarries over 18 per cent; chemically controlled industries 6 per cent; water works, government use and steam railroads, 4 per cent; flour mills, 3.4 per cent; general industries, 3 per cent and the remainder unclassified. In the last few years great strides have been made in the application of oil engines to marine use. Some passenger lines are equipped with as much as 20,000 hp. in one ship. In this service not only is the fuel economy enjoyed of importance but also the saving in space and labor and the absence of smoke and dirt. Mr. Chadwick stated that probably half of the ships being built at the present time are being equipped with oil engines.

No doubt, stated Mr. Chadwick, oil engines would be in much more extensive use in the ordinary run of industries, except for the very strenuous opposition put up by the central stations who have power to sell.

When a skilled mechanic repairs your automobile, does it belong to him or to you, after you have paid the bill? If you buy vacant land and erect a building on it, who owns it, you or the men who worked on the building? If you should sell at a profit, to whom should the profit belong? If you sell at a loss, who should stand it?

These are fundamental questions that ought to be answered by some visionary economists (?) when they advocate radical theories of property rights.

Workers have a right to fair, even generous return for their labor, to reasonable hours, good working conditions, the benefits of improved tools and methods and to offer or withhold their services. But why should this give them control of a property or an industry which has afforded them opportunity to work?

Plastic Furnace Lining Gives Long Service

PROPERLY INSTALLED SO THAT IT IS THOROUGHLY PRESSED INTO A UNIFORM MASS AND PROPERLY VITRIFIED IT WILL LAST LONG PERIODS UNDER THE MOST SEVERE FIRING

AS WITH everything else, one of the big factors governing results to be expected from a monolithic furnace lining is the way in which it is installed. Good material is of vital importance of course, but given the best of materials wrong installation methods are certain to cut down the life of the lining, or even result in some of the same faults which a plastic monolithic lining is designed to eliminate.

Some of the blame for faulty installation methods may be placed on manufacturers of plastic themselves. Because of the fact that it is simple and easy to install, manufacturers have, perhaps, overstressed the fact that "anyone" can install a good plastic lining. The result is that sometimes the simple fundamentals have been disregarded and too careless installation methods have been followed.

With high grade plastic, it is possible to produce walls and linings that will not only resist the high temperature and abrasive action of the flame, but will be free from spalling and cracking and will afford perfect protection to the necessary parts of the furnace over long periods of time.

SURFACE SHOULD BE ROUGHED SO SUCCESSIVE LAYERS BOND TOGETHER

When installing a lining, it is well to bear in mind a few fundamental principles. A common mistake is to use plastic simply as a plaster, expecting a thin layer to take the place of 8 in. of fire brick. It is highly important that a sufficient bulk of the material be used to give strength and rigidity as well as insulation. The material must be pressed solidly in place, so that progressive layers knit together completely. After one section has been pounded into place, the surface should be thoroughly roughed up with a trowel before the next layer is built so that the two sections will knit and bond together.

After the plastic has been pounded into position the exposed surfaces which have been densely compressed by the face of the mallet are practically air-tight. For this reason it is important that this dense skin of perhaps half-inch thickness be shaved off for the purpose of rendering the surface porous and providing easy escape for steam which is generated as the material dries out.

It is important, of course, that all walls stand on a firm foundation. When good strong support is not available, anchors should be provided capable of sustaining a wall. When the length of the wall is greater than 10 ft., it should be broken into sections by means of expansion joints. These are easily made by building a thin board into the wall and allowing it to burn away during the vitrifying process. The lining should not be run solid around corners, but each wall should be built separately and the lining installed in sections so that the part subjected to the greatest wear may be replaced without tearing out the entire lining. As described later, these sections can be installed with an air-tight joint.

After the material has been completely installed, the next step is to dry it out thoroughly before applying sufficient heat to effect vitrification. If air drying is depended upon, free circulation of air through the boiler should be provided for a period of at least four weeks in order to permit moisture to dry out the thickest section. Fire should never be used once the drying-out has been started by the air method. An attempt to hasten the drying after air drying has been started is certain to harm the lining and result in spalling, since the outer surface has dried first and confines the steam generated by the fire.

A more convenient way to effect the drying-out process is by means of a light banked fire, started as soon as the lining is installed. The object of this fire is to provide only enough heat to drive away the moisture over a period of 10 to 12 hr. Fire is built in the boiler keeping away from intense flame or heat as much as possible so that any wood from the supporting arches will not burn out during this period. As soon as the fire is well started it is banked with fuel to hold for about 12 hr. While the banked fire is effecting the drying out process, sufficient draft should be provided by leaving the fire doors open, so that there is plenty of air circulation to carry away the moisture.

SURFACE IS VITRIFIED BY THE FULL FIRE WHEN THE BOILER IS PUT ON THE LINE

At the end of the 10 or 12 hr. period, a full fire may be carried and the boiler placed on the line at once. Ordinary firing of the boiler then serves completely to vitrify and harden the plastic material into a solid monolithic structure.

Recently an installation demonstration was held by the S. Obermeyer Co. of Chicago, manufacturers of the plastic, Ramtite. Detailed directions and rules were given and these may be taken as indicating good practice for practically any high grade plastic material.

PRELIMINARY WORK

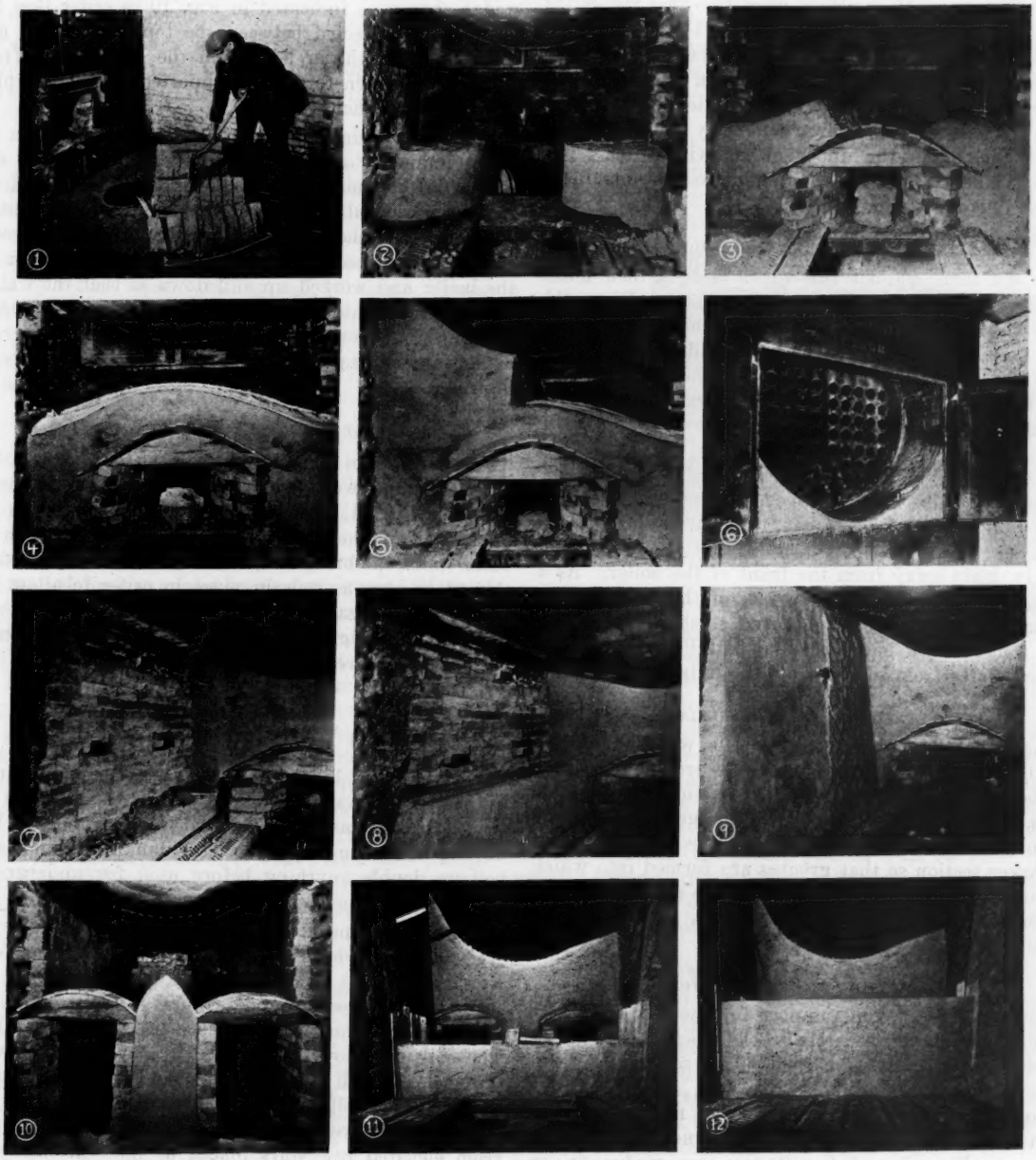
First the old lining should be torn away with the front wall removed completely up to the space of the boiler front. Side walls should be cut back at least 8 in., the tearing out being carried on from the first solid header above the grate down to an inch or so below the grate level. Time will be saved if all the old material is completely torn away and cleared out before trying to install the plastic.

To open the barrel, cut the four outside hoops with an ax, roll the barrel halfway over, cut all six hoops on the opposite side and remove the staves. With a spade or flat shovel, cut the plastic into pie-shaped pieces about four inches thick as shown in Fig. 1.

Start with the piers on each side of the fire door first. A layer of the pie-shaped chunks of plastic is put in place, some loose material scattered over it to fill in the interstices and a layer pounded solidly into shape with a 7-lb. mallet. When the first layer has been packed on, the top surface should be thoroughly roughed up with a trowel to provide for the next layer. A surface properly prepared for a new layer is shown in Fig. 7.

Piers should be shaped like those in Fig. 2, swinging in an arc from just beyond the edge of the fire door around to the side wall. When they have been carried up to the level of the top of the fire door the outside surface should be shaved off with a trowel in order to even it off to a smooth surface and remove the dense hammered material.

on the brick and the form boards laid on them and tightly tacked into place. The arch form should be set so that the top of the curve in the arch comes just below or even with the top of the fire door to protect the cast iron boiler front. If a smooth surface is wanted on the arch a sheet of building paper may be placed over the arch form before the plastic is applied.



FIGS. 1-12. OLD FURNACE LININGS SHOULD BE ENTIRELY REMOVED BEFORE STARTING TO INSTALL THE PLASTIC LINING

In order to permit installation of the arch across the fire door, a simple form can be constructed and supported on the pile of bricks placed beside the piers on each side of the door. This form consists of two wooden templates cut out with a hatchet or saw so that one of them gives the curve for the front of the arch and the other the curve for the rear of the arch. As shown in Fig. 3, the two templates are set in place

When the arch form is placed the material is carried up over the piers and completed across the arch as shown in Fig. 4. As the material is placed across the arch it should be installed in vertical layers, that is, against the face marked A in Fig. 3 beginning at each side and working towards the middle so that the pounding is against the side instead of down against the form. As shown in Fig. 4 the lower arch should have a

minimum thickness of 9 in. It is subject to the severest use and highest temperatures and should be built so that it may be replaced without removing the upper part known as the relieving arch.

Preparing Separation Between Door Arch and Relieving Arch

When the door arch has been completely formed a layer of cheese cloth is placed over it so that the entire surface with the exception of a strip 1½ in. or 2 in. wide is covered. This cheese cloth is visible on top of the covered lower arch in Fig. 4 and on the right-hand side of Fig. 5. This forms a separation between the two arches so that the lower one may be torn away without damaging the upper or relieving arch. The bare strip next to the inside is ample to prevent cracks from developing at this point.

Installing Relieving Arch

In the same manner the upper arch is then built, working from each side towards the center. When the entire wall is installed the surface should be shaved off. The thickness of the front wall should be enough to cover the front row of rivets on the boiler. This arch may be keyed into a common brick wall so that it is self-supporting.

Plastering in the Smoke Box

Since there is always danger of water leaking from the man-hole in the smoke box, it is important that the lining at this point be sloped so that the water will quickly drain away from the front of the boiler. As a further precaution the top surface of the lining inside the smoke box should be plastered as shown in Fig. 6 with a mixture of half sand and half Portland cement to keep water from soaking into the lining.

Installing the Side Walls

As with the front arch the side walls should be installed in two sections. In order to provide good keying between the upper and lower sections of the side walls, a section of 1 in. or 1¼-in. gas pipe can be pounded down about halfway into the top surface of the lower section so that grooves are formed into which the top section will key. The gas pipe is not left in place as shown in Fig. 8 but simply serves as a means of forming the grooves.

Anchoring the Top Section

In order to provide support for the top section, it should be anchored securely to the brick boiler setting providing an anchor for each 30-in. square. A convenient anchor is one made from 4-in. sections of 8-in. channel iron with a 2-in. web. A brick may be removed from the wall, laid in the channel and reinserted as shown in Figs. 7 and 8, with an iron wedge driven underneath the channel to wedge it securely in place. Anchors should be kept at least 4 in. from the surface of the wall exposed to the fire.

Before beginning to install the top section of the side wall a layer of cheese cloth covering all except a strip about 2 in. wide should be placed over the lower section and pressed down into the grooves. The wall is then built up in horizontal layers to a convenient working distance of the top and the top layer then installed working from side to side, after which about a half-inch of outer surface should be shaved off as shown in Fig. 9.

Installing the Smoke Arch

In installing the smoke arch a central pier at least 9 in. square should first be built up to the level of the arch proper. It is well to make the top of this pier wedge shaped as indicated in Fig. 10 in order that the best bond is effected between the top of the pier and other parts of the arch. As in the case of the front door arch, wooden forms are supported in place by piles of bricks on either side.

Plastic is installed first on one side and then on the other, pounding as much as possible towards the side walls. After the arch wall is completely in place, the surface is shaved off in the same manner as the other walls. When the wall has been completed a trowel should be inserted between the wall and the bottom of the boiler and worked up and down so that the wall is not in direct contact with the bottom of the boiler shell. A gap of ½ in. or so should be made in this manner for expansion. This gap may be filled with asbestos later if desired.

Installing the Bridge Wall

An expansion joint should be provided at each end of the bridge wall by inserting half-inch boards as shown in Fig. 11. These boards are left in position and burned away when the lining is vitrified. As with the other walls, the bridge wall should have all the surfaces shaved as soon as it is in place in order to allow free escape of the gas generated during vitrification and drying out. Figure 12 shows the completed furnace with the lining ready for drying out.

132,000 Volts Go Underground

Six miles of 132,000-v. cable has been put in service by the Commonwealth Edison Co. in the Chicago district. It was made by General Electric Co. on lines developed by the Pirelli Co. of Milan, Italy, and is for voltage double anything before used for underground lines in the United States.

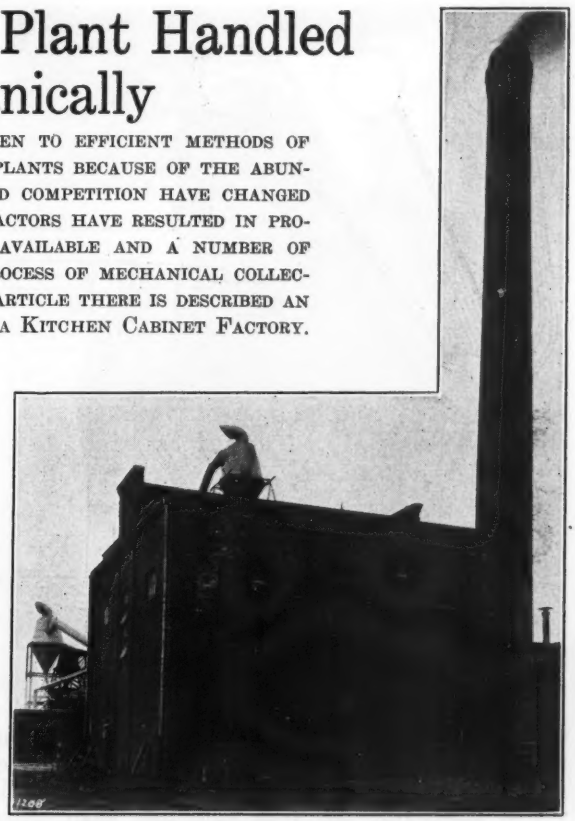
This line connects the Northwest station on California Ave. to the overhead lines of the Public Service Co. of Northern Illinois at a point ½ mi. from Crawford Ave. station. It consists of underground conduits containing three lead-sheathed cables, each a little over 3 in. diam. The core is hollow, surrounded by copper wires which are enclosed with layers of paper and a protective metal sheath. The hollow core is filled with oil under pressure, which impregnates the paper, the oil being supplied from elevated reservoirs placed at intervals along the line.

Capacity of the line is 100,000 kw., the present load being about half that.

Use of this line eliminates the transformer stations heretofore needed to step up from the old 33,000-v. underground lines to the 132,000-v. overhead system which extends to Milwaukee north, to Ohio east and is projected to Minneapolis, St. Louis, Detroit, West Virginia and the Atlantic coast.

Refuse Wood in Indiana Plant Handled and Fired Mechanically

UNTIL RECENT YEARS LITTLE THOUGHT HAD BEEN GIVEN TO EFFICIENT METHODS OF BURNING WOOD WASTE OBTAINED FROM WOOD WORKING PLANTS BECAUSE OF THE ABUNDANCE OF SUCH FUEL. INCREASING COST OF LUMBER AND COMPETITION HAVE CHANGED METHODS OF SAVING AND THIS COMBINED WITH OTHER FACTORS HAVE RESULTED IN PROPORTIONATELY REDUCING THE AMOUNT OF SUCH FUEL AVAILABLE AND A NUMBER OF EFFORTS HAVE BEEN MADE RECENTLY TO PERFECT THE PROCESS OF MECHANICAL COLLECTION, HANDLING AND BURNING OF SUCH FUEL. IN THIS ARTICLE THERE IS DESCRIBED AN INTERESTING INSTALLATION IN THE PLANT OF AN INDIANA KITCHEN CABINET FACTORY.



ON ACCOUNT of its reliability, steadiness and ease of operation, the fuel handling system installed in the heating plant of the kitchen cabinet manufacturing factory of the G. I. Sellers & Sons Company at Elwood, Ind. is an outstanding example of the progress made in the art of refuse wood handling and burning. Trouble occuring from arching of fuel in the bin, which usually accompanies use of hogged wood and sawdust; and danger from dust explosion, have been entirely overcome in this plant.

STEAM ONLY USED FOR HEATING AND PROCESS

Electric power and lighting current is purchased, but steam is required for process work such as dry kiln operation and for heating. Two 216-hp. Stirling water-tube boilers are used to furnish this steam. Steam pressure is held at from 75 to 85 lb. per sq. in. Rain water is used for the most part as feed water. More of this water, which is obtained from five acres of roof surface, is available than is necessary for operation, 50,000 gal. being required for make-up water. City water is used partly for cooling and partly to prevent too great acidity. The Metalene boiler metal treatment is used. This is designed to form a thin transparent film over the metal surface to prevent solids in the water from adhering to the metal. Water is drawn through the system by two vacuum pumps working at from 3 to 10 in. vacuum and passes to a receiver whence it goes to a feed-water heater. Two boiler feed pumps serve it to the boilers.

Steam lines extend a considerable distance in this plant. At one place they run 150 ft. underground in order to connect with buildings situated across a roadway. These pipes are located in a Ric-wiL tile construction, a cross section of which is illustrated in Fig. 1. An 8-in. steam line and a 4-in. vacuum return line are carried on rollers, as shown, to permit expansion. A 4-in. system line is located at the bottom. The round tile sets on hollow tile support which rests upon a concrete foundation and being open at the joints, drains the tunnel. The 8-in. pipe is covered with Banner Rock, the tunnel is lined with 2-in. mineral wool and the space around the piping packed with the same material. Construction of the stack, which is of radial brick and which is 110 ft. high and 5 ft. diameter at the top, was completed in 14 days.

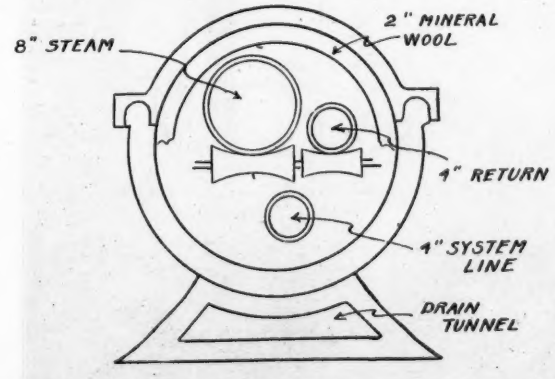


FIG. 1. CROSS SECTION OF TILE TUNNEL FOR STEAM PIPING SHOWING HOW EXPANSION IS PROVIDED FOR AND HOW TUNNEL IS DRAINED

VARIETY OF FUEL IS USED

Besides hogged wood, sawdust and shavings are regularly burned as fuel. During the winter months some coal is used. Provision is made for firing the latter over the grate by hand while the hogged fuel is being fed into the top of the furnace. A 20-in. fan draws the sawdust from the woodworking machines and passes it to the cyclone on the roof, from which it goes to the fuel bin. The suction on the line is from 7 in. to 8 in. on the machine farthest away from the fan. Hogged fuel is likewise passed through the cyclone to the bin.

All saw mill waste, which may average 40 per cent moisture, as well as all finishing mill refuse, which comes from kiln dried lumber usually not exceeding 6 per cent moisture, is used for fuel. Likewise no discrimination is made as to whether the wood is hard or soft.

Hogging is done in a "No-Nife" hog shown in Fig. 2. This is provided with a trap into which metal pieces

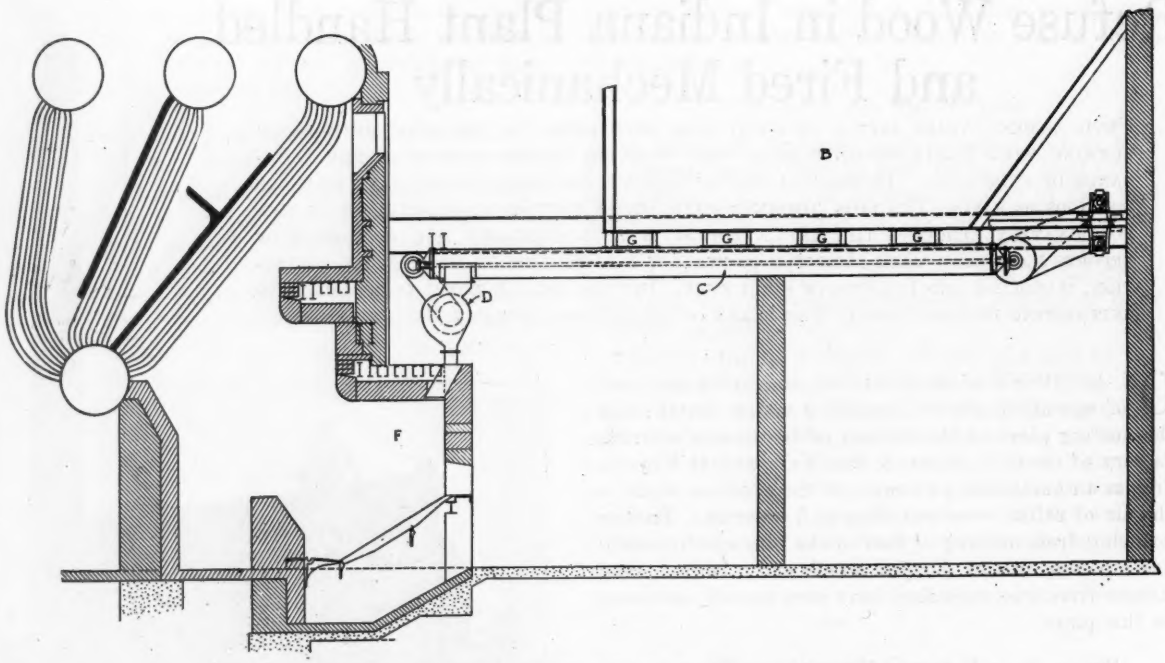


FIG. 3. LAYOUT OF NATIONAL STOKER, FURNACE AND FUEL FEEDING DEVICE

such as nails, spikes, bandiron, etc., coming into the hog with the wood, are thrown, thus permitting their removal at regular inspection intervals. As the action is one of hammering the wood slabs into small pieces rather than cutting, the machine is rarely damaged by the introduction of even heavy metal pieces and it will handle heavy slabs of wood with ease. This hog has a capacity of from 4 to 5 t. an hour. It is fed by a belt conveyor.

Figure 3 illustrates the boiler setting, furnace and method of feeding it. Hogged fuel, which has been collected in bin "B" passes through one or another of the four gates G. G. G. G. at the bottom of the bin to each screw conveyor C, and to its paddle wheel distributor which admits it at the top of the extension furnace F into the combustion space where it is consumed for the most part in suspension. There are two conveyors for each boiler. Each of the two boilers is similarly served with fuel.

Prevention of Arching in Fuel Bins

Formerly considerable trouble due to arching of hogged fuel was experienced. This is entirely overcome by the use of different openings at the bottom of the bin and by the supplementary use of compressed air at the bottom of the fuel bed to lift it in case of arching. To accomplish this latter, an air compressor shown in Fig. 4 supplies air at a pressure of 100 lb. per sq. in. through a receiver to pipe lines discharging in the bottom of the fuel bed in the bin. When the air pressure is applied it raises the fuel and breaks down the arch. Usually arching is overcome by simply opening a gate adjacent to one at which arching has occurred. This breaks down the wall of the arch on the

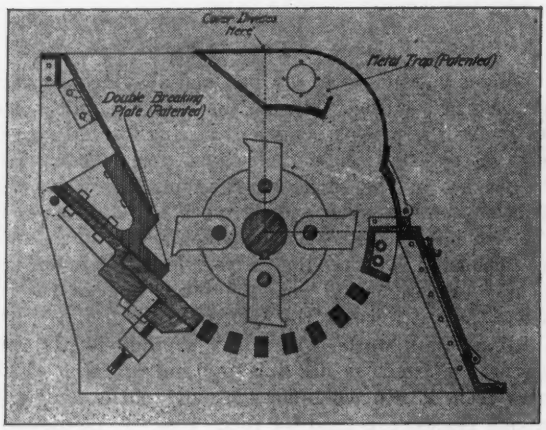


FIG. 2. CROSS SECTION OF ALL STEEL HOG FOR SLABS, BLOCKS AND HEAVY REFUSE SHOWING METAL TRAP FOR THE REMOVAL OF SPIKES AND SIMILAR METAL PIECES

FIG. 4. SHOWING ARRANGEMENT OF AIR COMPRESSOR AND GEAR AND CHAIN DRIVES FOR THE CONVEYORS

one side and steady flow of fuel is resumed. The size of the openings in the gates is 10 in. by 12 in.

Motor drives and transmission gearing for the fuel conveyors are shown in Fig. 4. Each pair of conveyors serving a boiler is supplied with one drive. Motors used for this purpose are rated at 3 hp. Speed reduction is accomplished by means of gears and chain drive as shown. The normal speed of the conveyors serves the fuel at a rate of 30 ft. per min. The speed is varied according to demand by means of R-K step action hydraulic regulators which act through dial switch rheostats governed by the steam pressure of the boilers. Increase in boiler pressure increases the resistance in the rheostat and slows down the motor, thereby decreasing the speed of the fuel conveyor.

Relation of conveyors, paddle wheel distributors and boilers is shown in Fig. 5. Another view of the paddle wheel distributor showing the interior construction is illustrated in Fig. 6. The functions of this distributor are to prevent an over influx of air when the fuel is admitted to the furnace and also provide against any possibility of avalanching of fuel or back firing and as a precaution against fire. It also aids in distributing the fuel over a larger area than would be the case if it was admitted through a pipe or similar circular opening.

Danger From Dust Explosion Avoided

In any wood burning furnace in which at least some of the fuel is very fine, quantities of this fine combustible dust collect around the boiler front. There is, therefore, great danger from fire since if the building were jarred or a draft swept this dust in the air at the moment at which the furnace is fired by hand through the open furnace door, a dust explosion, which may destroy the entire plant, is possible. This danger has been eliminated in the Sellers plant by the use of a hotel type vacuum cleaner which is used to collect the fine dust before it accumulates.

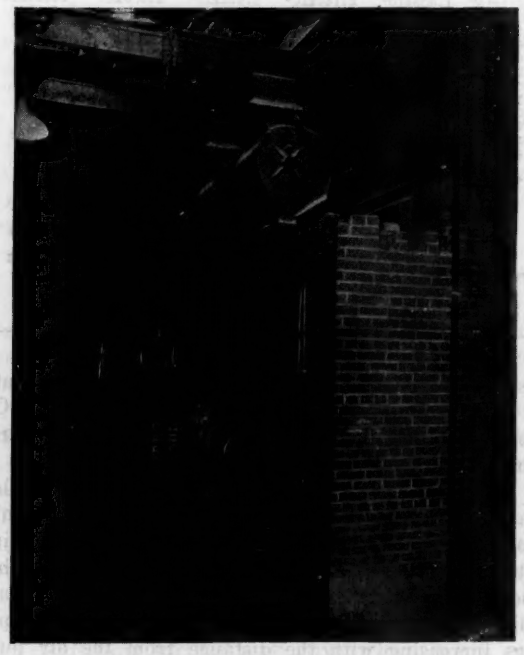


FIG. 5. VIEW OF BOILER FRONT SHOWING FUEL CONVEYORS AND PADDLE WHEEL DISTRIBUTOR

FIG. 6. PADDLE WHEEL DISTRIBUTOR WITH CASING LID RAISED TO SHOW CONSTRUCTION OF WHEEL

Messrs. Snider & Rotz of Indianapolis, Ind., were the consulting engineers.

Principal Fuel Burning Equipment of Sellers Plant

2—216-hp. Stirling boilers—Babcock & Wilcox Co.
2—12 by 12 by 12-in. vacuum pumps—Dean Brothers Company.
2—6 by 4 by 6 duplex boiler feed pumps—Dean Brothers Company.
1—400-hp. Cochrane feed water heater—Cochrane Corp.
Boiler metal treatment—The Metalene Chemical Co.
2—Stokers, 8 ft. by 6 ft., arches and fuel handling apparatus—M. A. Hofft Co.
Smoke stack, 110 ft. high, 5 ft. diameter at top, radial brick—J. M. Cutshall & Sons.
1—Hogging machine, "No Nife" type, with metal trap —The Williams Patent Crusher & Pulverizer Co.
1—Cyclone—Cyclone Blowpipe Co.
2—Fuel regulators No. 3 R-K step action hydraulic damper regulators — Ruggles-Klingemann Mfg. Company.
2—Rheostats—General Electric Co.
1—Blower.
1—Air compressor—Gardner Governor Co.
1—Vacuum cleaner, "Tuec" hotel type—United Electric Co.
Piping installed by Hayes Bros.

Of the 23 billion kw-hr. output of central plants last year, 32 per cent was produced by waterpower and 68 per cent by fuel.

Twin Condensers Installed at Bradford Station

COMPLETE TESTS OF TWIN CONDENSERS INSTALLED UNDER DOUBLE EXHAUST TURBINES IN THIS BRITISH STATION WHERE THE ARRANGEMENT OF EQUIPMENT DIFFERS MATERIALLY FROM STANDARD AMERICAN PRACTICE

FEW THOROUGH and complete condenser tests of modern surface condensers have been published so that results of tests of the Valley Road power station of the Bradford Electricity undertaking recently published in "Engineering" are of unusual interest and a valuable addition to technical data.

This installation consists of spring mounted twin condensers with a total surface of 35,000 sq. ft. made up of ¾-in. No. 19 S. W. G. admiralty tubes 16 ft. long tinned inside and out. The condensers are of two pass

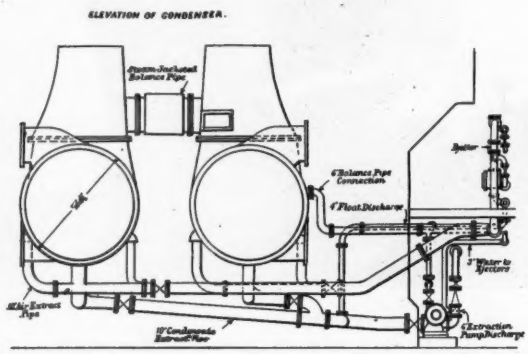


FIG. 1. A DIAGRAMMATIC ARRANGEMENT OF THE EQUIPMENT AND AN ELEVATION OF THE PLANT INDICATE THE GENERAL SCHEME OF ARRANGEMENT

up, there has been but a slight drop in efficiency over a period of a year. The scale formed is soft and easily cleaned out with rubber plugs blown through by 50 lb. air. In fact, the tests described were made with no previous cleanings of the tubes, after several months' operation, and the guarantees were exceeded in every

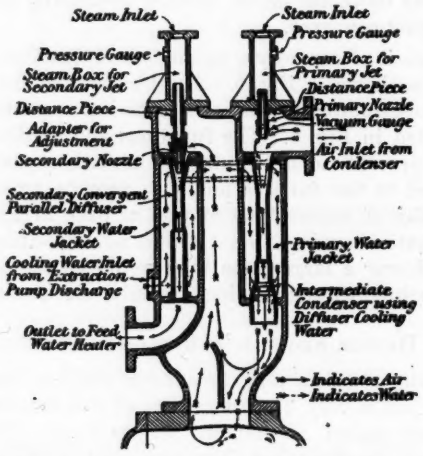


FIG. 2. INTERSTAGE COOLING OF THE EJECTORS IS ACCOMPLISHED BY A COMBINATION WATER JACKET AND JET ARRANGEMENT

TABLE I. COEFFICIENTS OF HEAT TRANSFER AS HIGH AS 622 WERE OBTAINED

1.	Weight of condensate, lb. per hr.	132,384	189,498	188,478	221,623	169,936	243,195	245,211
2.	Heat units passing into condensate, B.t.u. per hr.	1.282×10^8	1.815×10^8	1.803×10^8	2.140×10^8	1.632×10^8	2.350×10^8	2.367×10^8
3.	Quantity of circulating water, gal. per min.	27,950	30,460	29,970	31,070	30,660	29,760	28,800
4.	Speed of water through tubes, ft. per sec.	5.778	6.300	6.193	6.424	6.340	6.157	5.956
5.	Temp. of circulating water at inlet, deg. F.	71.46	66.42	68.41	65.71	68.54	69.65	70.75
6.	" " " " "outlet, " "	79.11	76.35	78.44	77.19	77.41	82.80	84.44
7.	" " " " "end of first passage, deg. F.	74.25	72.28	73.95	72.05	73.65	77.05	78.36
8.	Mean temperature of circulating water, deg. F.	74.59	73.65	73.77	71.85	73.43	76.77	78.10
9.	Absolute pressure at turbine exhaust, in. of Hg.	1.13	1.04	1.14	1.11	1.08	1.36	1.44
10.	Corresponding temperature, deg. F.	82.65	80.2	82.92	82.16	81.2	88.6	90.4
11.	Observed temperature at turbine exhaust, deg. F.	82.74	79.33	81.00	78.11	79.31	85.2	86.3
12.	Heat flow per square foot of tube surface, B.t.u. per hr.	3,665	5,186	5,151	6,114	4,662	6,240	6,763
13.	Deduced mean temp. diff. between steam and water, deg. F.	8.06	6.55	9.15	10.31	7.77	11.83	12.30
14.	Value of $\frac{t_2 - t_1}{\log_e \frac{t_s - t_1}{t_s - t_2}}$, deg. F.	6.645	7.787	8.517	9.590	7.355	11.10	11.48
15.	Coefficient of heat transfer per hr., $\frac{\text{B.t.u. per deg.}}{\text{per square foot}}$	566	655	599	621	622	602	596
16.	"Theoretical" coefficient (clean tubes, air-free steam)	642	668	677	677	674	679	673
17.	Temperature of condensate, deg. F.	78.50	79.7	81.5	80.7	80.4	86.3	88.0
18.	Pressure drop across tubing, in. of Hg.	0.01	0.04	0.06	0.05	0.02	0.09	0.11
19.	" " in air extraction pipe, in. of Hg.	0.01	0.05	0.06	0.06	0.05	0.05	0.07
20.	Ratio of air to steam in extraction pipe, per cent	16.5	7.7	5.1	3.9	11.2	7.9	2.1

design with 2785 tubes in each pass, three intermediate tube supports giving an unsupported tube span of about 4 ft. They are set under a 20,000-kw. turbine with two exhaust openings and in order to insure equal pressures on both openings a balancer pipe has been installed as shown in the elevation in Fig. 1. The turbine is set on a steel frame work completely encased with concrete.

Specifications called for a plant capable of maintaining a vacuum of 28¼ in. with 29,500 g.p.m. of 75 deg. water when condensing 240,000 lb. of steam per hr. This corresponds to a water velocity of 6.1 ft. per sec. in the tubes. Circulating water is cooled with cooling towers but, because of the excellent quality of the make-up, there has been but a slight drop in efficiency over a period of a year. The scale formed is soft and easily cleaned out with rubber plugs blown through by 50 lb. air. In fact, the tests described were made with no previous cleanings of the tubes, after several months' operation, and the guarantees were exceeded in every case. Two 960 r.p.m. motor-driven hotwell pumps rated at 520 gal. against a head of 45 ft. are used. One motor is for alternating current and the other for direct current and both are rated at 28 b.hp.

Each condenser is supplied with two air outlets. These outlets connect with internal air ducts running along the shell from end to end and having openings into the condensing space at a number of points. These openings are graduated in size so as to secure a nearly uniform flow of air through each, the size of the openings increasing with the distance from the air pump suction. Three two-stage air ejectors are supplied, each of the three units being designed to handle 65 lb.

of air per hr. at 28¼ in. vacuum when using 190 lb. gage steam at 650 deg. F. Under these conditions the primary ejector uses 437 lb. per hr.

Cooling water required for the air ejectors is taken from the hotwell pump discharge with an auxiliary connection to the city water supply for use when starting up. Cooling water enters near the outlet of the secondary stage and flows upward through a water jacket enclosing the secondary jet diffuser. From here it flows to the top of the primary jet water jacket which is arranged at its lower end to act as a jet condenser. The condensate together with the cooling water is then led through a barometric pipe to the suction pipe of the hotwell pump. The air passing upward is caught by the second stage steam jet and delivered to the feed water heater inlet as shown in Fig. 2.

TABLE II. TEST RESULTS SHOW THAT THE CONDENSER GUARANTEES WERE EXCEEDED AT ALL LOADS

Circulating water, quantity per hour, lb.	17,700,000	17,700,000	17,700,000	17,700,000
Steam condenser, lb. per hr.	140,000	190,000	240,000	260,000
K-l garithmic heat transfer constant,	562	638	608	576
Inlet temperature t_1, deg. F.	70	5	70	70
Outlet temperature t_2, deg. F.	82.62	85.25	88.07	89.25
Temperature of steam	96.15	99.41	93.77	92.92
Absolute pressure of steam	1.26	1.40	1.60	1.71
Actual vacuum, inches of mercury	29.74	29.60	29.40	29.29
Guarantee vacuum, inches of mercury	29.49	29.29	29.25	29.18
Improvement over guarantee, inches of mercury	0.25	0.22	0.15	0.11

Condenser leakage tests showed that the total leakage did not exceed 1 lb. per hr. all thermometers were calibrated against standard instruments and the necessary calculations applied when tabulating the final results. The drop of pressure between the top and bottom of the condenser ranged from 0.01 in. when condensing 132,000 lb. of steam per hr. up to 0.11 in. of mercury when condensing 245,000 lb. of steam per hr. With one exception, each trial lasted an hour, giving 13 readings of each instrument. The mean of these was taken as a true reading. In some of the tests air was purposely admitted to the condenser in order to give the desired vacuum, but these runs have been ignored when comparing the trial results with the guarantee.

Tabulated test results are given in Tables I and II. The logarithmic temperature difference is given in line 14 and as careful readings were made of the temperature of the circulating water at the end of the first pass, the mean temperature of the circulating water has been calculated from the formula.

$$T_m = \frac{T_1 + 4T_{\frac{1}{2}} + T_2}{6}$$

where T_1 = temperature of incoming water, $T_{\frac{1}{2}}$ = observed temperature at end of first pass, and T_2 = temperature at discharge.

The figures in line 13 in Table I have been calculated on this basis and in certain cases it will be seen, differ considerably from those given by the logarithmic formula.

The theoretical coefficient of heat transfer has been determined by a calculating from tables published in "The Laws of Heat Transfer." They apply to tubes with absolutely clean surfaces and to steam which is entirely air free. It is moreover assumed that the whole of the condensing surface is effective, which it will not be if part of the tubes are drowned by condensate collecting in the bottom of the shell.

Effect of Steam on Economizer and Air Preheater Surfaces

LIFE of the heating surfaces of economizers and air preheaters is decidedly affected by the quantity of moisture which precipitates from the flue gases. As soon as the flue gases are cooled to the dew point, the moisture precipitates; this causes corrosion and, in the presence of SO_2, also an early destruction of the iron. The precipitation is greatest where the heating surfaces are coldest, namely at the intake of the fresh water or the air.

It has been determined that when the temperatures of the flue gases are the same in both cases and the water temperature in the economizer is the same as that of the air in the preheater, the average wall temperature of the air preheater is much higher than that of the economizer, and that it lies only slightly below the average of the temperatures of the two heat-exchanging elements. In the economizer, however, the average wall temperature is close to the water temperature, due to the very effective heat transmission from the water to the economizer surface.

It is evident that under the same operating conditions the steam precipitation on the air preheater surface is much less than on the economizer surface, due to the higher wall temperatures. This fact is of great value for the application range of air preheaters, for it is possible, by the use of fuels with high water content where the flue gas losses are an important item, to utilize the flue gases to a greater extent in the air preheaters than in the economizers.—Archiv. fuer Waermewirtschaft.

Veteran Engine Approaches 50-Yr. Mark

IN 1881 the American Steel & Wire Co. installed a Reynolds Engine in its factory at DeKalb, Ill. This was a 20 by 42-in. non-condensing Corliss belted to a

line shaft. A number of years later the Allis-Chalmers Mfg. Co. sold them a 38 by 42-in. low pressure cylinder of the same design to go alongside of the non-condensing engine to make a cross-compound engine exhausting to a barometric condenser.

Now the engine has two flywheels and is connected by two belts to the same line shaft, an unusual arrangement which gives it the appearance of two separate and distinct engines. The engineer, Gust. Carlson, started as an oiler in 1883 and has been with the engine constantly since that time. A short while ago he received a silver medal denoting 40 yr. service with the company.

A set of cards he recently took from the engine are reproduced in the illustration. They give no indication that the engine is well on its way towards celebrating its 50th birthday, as it no doubt will, because it is still in excellent condition.

Industry Finds Many Uses for Small Turbines

BESIDES MOST COMMON USES IN DRIVING GENERATORS AND PUMPS, TURBINE HAS BEEN APPLIED TO DRIVING STOKERS, PAPER MACHINES, UNIT PULVERIZERS AND THE LIKE

IT IS THE PURPOSE of this article to call attention briefly to some of the varied uses to which the steam turbine, particularly in the smaller sizes, is being put in industry, not only in power plants but also in connection with industrial processes and drives for industrial machinery. There is always a tendency for the engineer to think of the steam turbine as a prime mover for electric generators, centrifugal pumps and fans. It is true that these are its principal uses. For those industries that have large demands for process steam, various types of non-condensing, high back pressure, bleeder or mixed pressure turbines driving generators have been developed.

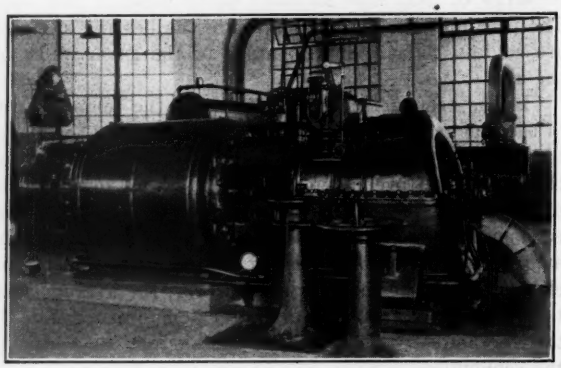


FIG. 1. 750-KW. MIXED PRESSURE CONDENSING GENERATOR SET USES EXHAUST FROM FORGING HAMMERS

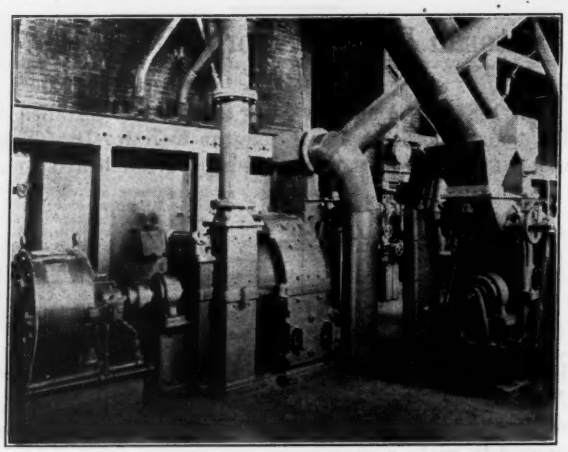


FIG. 2. TURBINE DRIVES UNIT PULVERIZER, EXHAUST GOING TO FEED WATER HEATER

For many other drives in industry, however, the small steam turbine has proved suitable when its exhaust can be utilized in some way, such as for heating feed water, domestic hot water, and for process work. Some of these applications are shown herewith. It is not to be inferred that these examples cover all the applications that have been made of the small steam turbine. Neither is any comparison implied between the small steam turbine and the electric motor or steam engine for drives of this type. Careful analysis of industrial drives will show that each type of drive has its legitimate uses, depending on the requirements of the drive and the possibility of economical use of the exhaust from a small steam unit.

As previously stated, the steam turbine is used in many industrial power plants for driving electric generators. In some cases they are operated straight condensing, in others straight non-condensing, exhausting at various back pressures for process work while between these two, turbines are found operating with extraction for process steam. In many industries using large quantities of steam in forging hammers or similar equipment, the exhaust from these is often brought back to a mixed pressure turbine. In recent years many developments have taken place in the use of geared units and these can now be supplied to give quiet, efficient and reliable performance under all conditions.

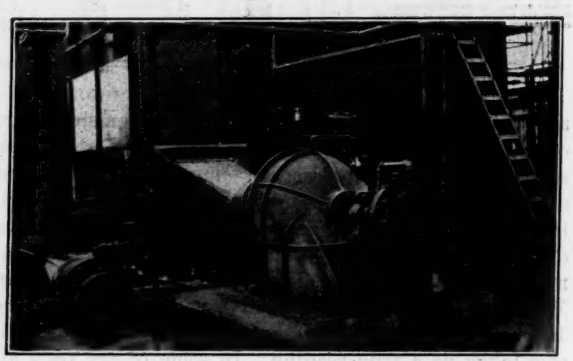


FIG. 3. LARGER TURBINE DRIVEN BLOWER HANDLES HOT FLUE GAS IN OIL REFINERY, SMALLER ONE HANDLES COLD AIR

GENERATOR DRIVES

Figure 7 shows a typical condensing generating unit. It is rated at 3000 kw. takes steam at 180 lb., 125 deg. superheat and exhausts at 28 in. of vacuum. Although the unit shown operates in a municipal lighting plant, it is typical of certain types of industrial installations. One of the principal applications of condensing units is in plants that produce large quantities of waste fuel or waste heat but do not have high process steam demands. Such conditions are sometimes found in large woodworking factories, cement mills and the like.

At the power plant of a large university, three turbines send their exhaust partly to hot water heaters of a large building heating system and partly to condensers, depending on the weather and electric load conditions.

Design, operation and applications of the extraction turbine are beyond the scope of this article and will be treated in detail elsewhere. Careful study is necessary to secure proper balance of the exhaust steam and electric load in applying such units. Several interesting

industrial installations of extraction turbines have been and are now being made from which valuable data will be secured.

It will be seen that the foregoing conditions may require a variety of turbine designs. One manufacturer, however, has developed a series of turbine sections that can be put together in various combinations to suit the conditions.

Figure 1 shows a typical installation of a mixed pressure turbine driving a direct-connected 750-kw. generator to furnish power for the plant of a large machinery manufacturer. In this plant are a number of forging hammers, the exhaust from which is brought back to the second stage of the turbine, while high pressure steam is supplied at the throttle.

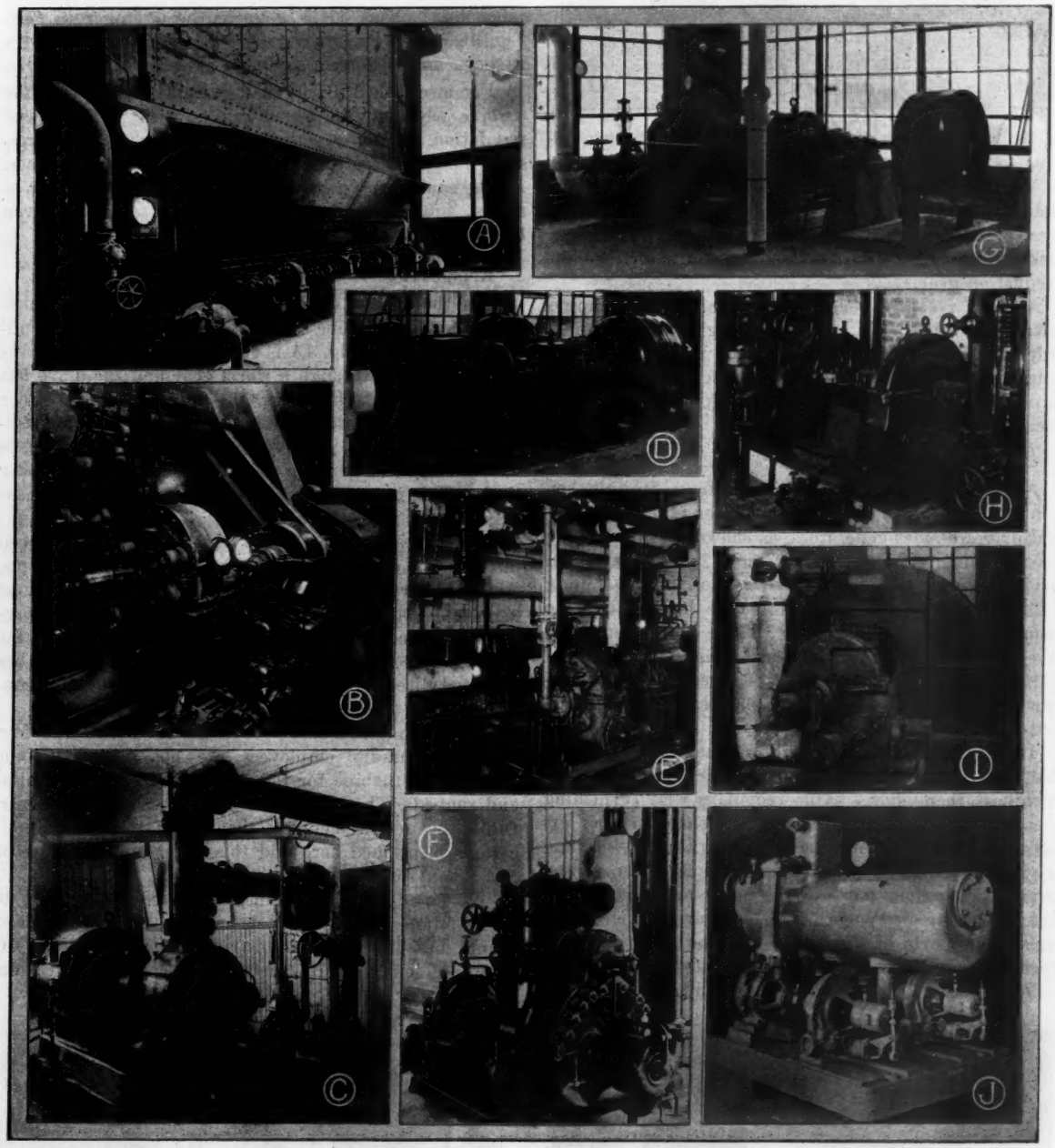


FIG. 4. A—TURBINE DRIVING UNDERFEED STOKER THROUGH WORM GEAR. B—GEARED TURBINE DRIVING YANKEE PAPER MACHINE. C—LOW PRESSURE CENTRIFUGAL PUMP DRIVEN BY DIRECT-CONNECTED TURBINE. D—TWO GEARED TURBO-GENERATOR SETS. E—BOILER FEED PUMP DRIVEN BY TURBINE EXHAUSTING TO PROCESSES AT 75 LB. GAGE. F—TURBINE DRIVEN CENTRIFUGAL FIRE PUMP. G—GEARED TURBINE ON VARIABLE SPEED PAPER MACHINE DRIVE. H—ANOTHER CENTRIFUGAL PUMP DRIVE. I—TURBINE DIRECT-CONNECTED TO FORCED DRAFT FAN. J—TWO HEATING SYSTEM VACUUM PUMPS DRIVEN BY TURBINES

Geared turbo-generator units are finding increasing

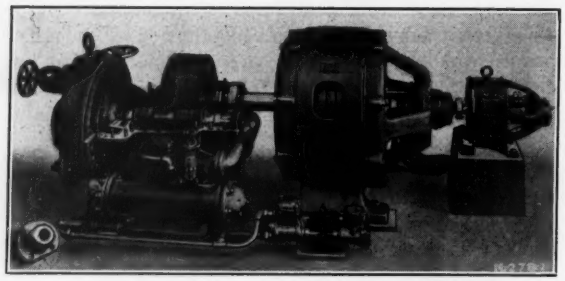


FIG. 5. GEARED TURBINE UNIT WITH ROTOR OVERHUNG ON PINION SHAFT

application. Figure 4D is typical of such installations. Here are shown two turbines exhausting to process work at 40 lb., each driving a 250-kw. alternator through a reduction gear.

Another recently developed type of geared turbine unit is shown in Fig. 5. This is a single-stage machine, built in sizes from 50 to 500 kw., the rotor being overhung on the pinion shaft and the gear shaft being coupled directly to the generator shaft or other driven machine.

Turbines Drive Unit Pulverizers

As previously noted, the small steam turbine has been successfully applied to many other types of industrial drives besides generators, as shown by some of the accompanying photographs. Figure 2 shows a steam turbine driving a unit pulverizer. Four of these units are installed to serve two water-tube boilers to make steam for a large paper mill. These pulverizers each have a capacity of between 2 and 3 t. and each is driven at 1800 r.p.m. by a 60-hp. direct-connected turbine, exhausting at a little above atmospheric pressure to the feed-water heater.

Interesting applications of the steam turbine have also been made in paper mills for driving the paper machines themselves. One company is furnishing a complete drive consisting of a steam turbine, exhausting to the paper machine rolls for drying and driving a generator which supplies power to motors driving the various parts of the paper machine. These motors operate in synchronism to secure proper speed for various parts of the paper machine and the entire mechanism, including turbine, generators and motors, is controlled electrically as a single unit.

Figures 4B and 4G show other types of turbine drives for paper machines. Figure 4B shows a 110-hp. turbine operating at 3600 r.p.m., driving a Yankee paper machine through a reduction gear. The drying rolls of these Yankee machines are 12 ft. in diameter with 132 in. face and weigh about 30 t. The turbine exhausts at about 35 lb. gage to the drying rolls. In Fig. 4G, a 250-hp. variable speed paper machine drive is shown installed in a southern paper mill.

For mechanical drives such as the two foregoing, the turbine permits wide speed ranges with precise speed regulation, operates smoothly, uses high steam pressures and temperatures and occupies small floor space. At the same time, it supplies clean steam for drying at almost any pressure required—50 lb. gage, or even higher.

Application to Stokers and Other Equipment

For the driving of mechanical stokers, various makes of small steam turbine have had many interesting applications, of which Fig. 4A is typical. The turbine drives the stoker shaft through a worm gear and the drive has great flexibility in handling speed changes, using either manual or automatic control. In this particular installation the turbine is used on a dual drive system, a motor being conected to the other end of the stoker shaft. This insures stand by service and control of heat balance.

Another interesting use to which turbines have been put is in the driving of centrifugals in laundries. Since these are vertical machines, the vapor rising from them may cause trouble in a motor drive, unless it is protected. Since most laundries need exhaust steam for heating water, a turbine may be used here, either mounted directly on the shaft of the centrifugal or connected to it through gearing.

Owing to the character of this drive and the fact that the laundry employees are not skilled turbine operators, a turbine for this service must be substantial and rugged. The turbines now on the market, however, fulfill this requirement, as they do in the other applications mentioned here and this point may be more or less taken for granted.

As noted above, turbines are frequently used to drive pumps and fans, not only in industrial power plants, but also in the industrial processes. Figure 4C shows a low-pressure vertical-split-casing centrifugal

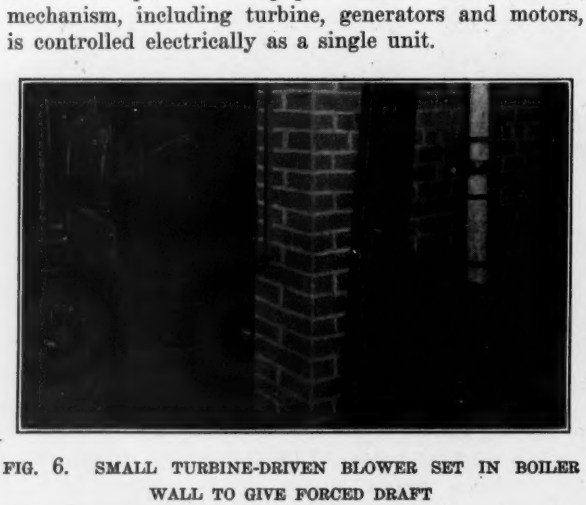


FIG. 6. SMALL TURBINE-DRIVEN BLOWER SET IN BOILER WALL TO GIVE FORCED DRAFT

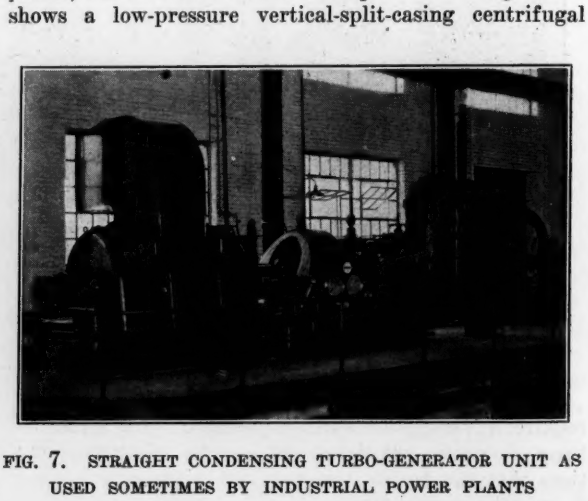


FIG. 7. STRAIGHT CONDENSING TURBO-GENERATOR UNIT AS USED SOMETIMES BY INDUSTRIAL POWER PLANTS

pump driven by a small turbine. In Fig. 4E is shown a turbine-driven boiler feed pump. The 50-hp. turbine, direct connected to the pump, drives it at 2100 r.p.m. to supply 250 g.p.m. Turbine exhausts at 75 lb. gage to supply steam for absorption refrigerating machines, some industrial processes and heating. This exhaust steam replaces about half of the live steam formerly used for these purposes and it has been estimated that the value of this live steam saved for the first year is about equal to the first cost of the equipment.

Figure 4F shows a turbine driving a centrifugal fire pump, an application of both units that has been increasing in recent years. The pump is a single-stage centrifugal designed to deliver 1500 g.p.m. against 100 lb. pressure. Another centrifugal pump drive is illustrated in Fig. 4H.

Steam turbines have also found application in various types of heating system equipment for driving fans and pumps. The vacuum pumps in Fig. 4J are driven at 1200 r.p.m. by turbines, the exhaust from which is piped into the return heating system.

For driving fans and blowers, the turbine is applied as shown in several of the illustrations. In Fig. 4I, a turbine is shown direct connected to a forced draft fan for a boiler.

In Fig. 3, two small turbines are shown. The one at the right drives a hot gas blower for circulating flue gas in the cracking process of an oil refinery, handling gas at temperatures up to 1100 deg. The smaller turbine-driven blower at the left handles cold air for the preheater. Many engineers are familiar with the application of the small turbine-driven blower shown in Fig. 6 installed in the side wall of a boiler to furnish forced draft.

Geared turbine units have also been applied to the driving of fans in the steel and cement industries.

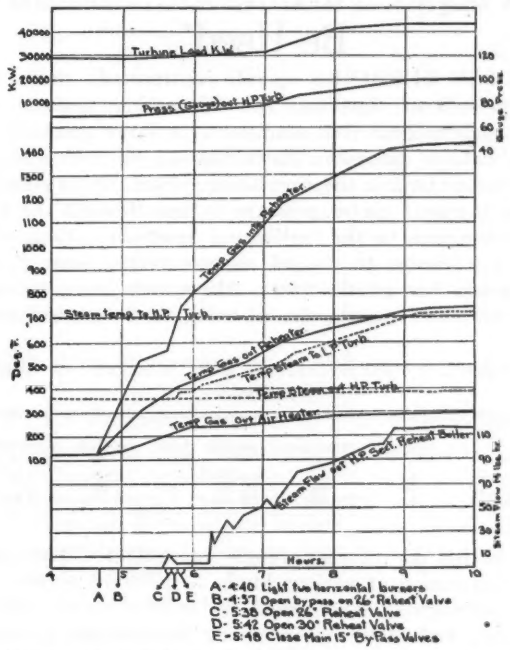
General Considerations

In conclusion, it should be emphasized that the application of small turbines to the types of drives shown here is not primarily a mechanical problem but rather a problem in heat balance. In other words, if a method can be worked out, under a given set of conditions, for utilizing steam at a given exhaust or bleed pressure and a certain amount of by-product mechanical or electrical power, the turbine manufacturers can supply a turbine that will satisfy those conditions from both the thermal and mechanical standpoints. It may be that exhaust steam from other steam units can be further utilized in a mixed pressure turbine. The analysis of the heat balance is sometimes simple and sometimes complex, but such an analysis can and should always be made.

For drives such as are shown here, turbine manufacturers always keep in mind the fact that turbines may be installed in basements or other out of the way places where they may not always receive a great deal of attention, accordingly they have designed small turbines for ruggedness and simplicity, devoting considerable care to the governing mechanism and the materials used for blades and shafts. The result is that the small turbine has been developed to give good mechanical operation under a wide variety of services and merits careful consideration by industrial engineers.

Reheat Boilers Started Slowly

DATA REGARDING the operation of reheat boilers at Columbia Station were given in a recent N. E. L. A. report. No unusual conditions have been encountered. Turbine and reheat boiler operation when putting the reheat boiler on the line from a cold condition with the turbine carrying a load of 30,000 kw. are shown by the curves. At 4:40, two middle horizontal burners were ignited. Shortly after this operation, the drains on the reheat piping and valves, and the bypass valve on the 26-in. main reheat valve were opened.



REHEAT BOILER CONDITIONS AT COLUMBIA STATION AS UNIT IS PUT INTO SERVICE

This operation allows the steam to circulate through the reheat piping and coils. Observation of the trap discharges and open drains from the piping serves as a guide to tell the operator how long the warming up period should last. When the pressure in the reheat piping and coils becomes equal to the high pressure turbine outlet pressure and the drains indicate that condensation has stopped, the 26-in. reheat inlet valve is opened. The opening of this valve occurred at 5:38. At 5:42, the 30-in. reheat outlet valve was partially opened and was fully opened at 5:47.

Up to this operation, it is essential to maintain the proper temperature conditions in the boiler. It has been found that the temperature of the gases entering the reheater should not be allowed to exceed 550 deg. F. during this period. Should the gas temperature exceed this value to any great extent, the steam within the reheater coils becomes highly superheated and causes a rapid temperature change at the inlet to the low pressure turbine when the reheated steam is cut in.

After the 26-in. and 30-in. reheat valves have been opened, the two 15-in. main reheat bypass valves are slowly closed. This operation was completed between 5:48 and 5:52. While these valves are being closed, the

fireman must gradually bring up his fire to maintain the proper steam temperatures. The curve indicates that the boiler was brought up to the full load reheat condition in approximately 3½ hr. The steam temperature entering the low pressure turbine shows a gradual increase in temperature from the time the main bypass valves are closed until the maximum temperature of 720 deg. F. is reached. Temperature changes of the steam inside the reheater are not rapid due to the large mass of metal in the reheat coils.

Proper Turbine Oil Should Be Used*

STEAM TURBINES operate continuously over long periods of time and the lubrication systems are designed to meet this condition. A large quantity of oil should be carried in the turbine oil reservoir and the oil storage tank in the circulating system. Oil is pumped from the tank under pressure to and through the turbine bearings to the turbine oil reservoir. From this point it drains to the oil storage tanks, part of the oil going through the filter. The system is an enclosed self-contained circuit, the oil being used over and over.

GOVERNMENT SPECIFICATIONS FOR TURBINE OR DIESEL ENGINE OIL

Oil	Flash Point Min. deg. F.	Fire Point Min. deg. F.	Viscosity Saybolt	Color A.S.T.M. No.	Pour Point Not above	Carbon Residue Max. per cent
Light oil	325	365	150–250	7	35° F.	0.20
Medium oil	335	380	270–350	7½	40° F.	0.45
Heavy oil	345	390	360–440	8	45° F.	0.55

As the oil travels through the system it may meet contamination of various kinds at different points. In the bearings it is subjected to heavy pressure, violent friction and heat. After leaving the bearings it churns with air as it enters the turbine reservoir and sump tank. It may pick up moisture in the tanks due to atmospheric condensation, in the bearings due to leaky steam glands and in the cooling coils due to leaks.

Oxidation from air contamination is one of the most prolific causes of change in a turbine oil. This increases the acidity, turns the color of the oil darker and usually promotes emulsion with water. Some oils that are entirely satisfactory for turbine lubrication when new will, after 5000 hr. use when violently churned with air and water, form emulsions that are difficult to break up.

Water in a turbine oil circulating system serves as an emulsifying agency. While in circulation through the system the water will not separate out. A short rest will, however, generally suffice to settle out most of the water provided the proper grade of oil is in use. One source of trouble in this respect is the presence of boiler compound or other contamination from boiler water that may leak through the turbine glands. Settling occurs in the oil storage tank and in the filters. The greater the amount of oil in the circulating system the more opportunity there is for settling.

A peculiar phenomenon takes place when air contamination causes an increase of acidity in the presence of water contamination. In this case if the water is settled out it will be found to be more acid than the oil. It would appear that the acid in the oil is in part washed out by the water. Advantage is taken of this fact to keep the acid content of a turbine oil low by continuously draining the water from it during operation. This, of course, reduces its affinity for water and consequently the amount of emulsification that will take place. The life of the oil is increased thereby.

Flash and fire tests for a turbine oil are not of any importance as long as it is evident that the oil is a straight mineral oil and not a compound of a heavy and a too light mineral oil. In the latter case the oil consumption would be increased because the lighter products would evaporate more rapidly and leave the heavier oil which might also have a tendency to gum.

Color in the new oil is of no importance. Whether the natural color be a light yellow or a dark red according to the manner in which it is manufactured, it will turn darker in color after use in a turbine system. This darkening is a perfectly natural action, the amount of color change being more apparent in a naturally light oil than in a dark one.

New turbine oil should be as low in acidity as possible. Filtering, a highly expensive process used in finishing special oils, will give the minimum acid content. All turbine oils build up in acidity, while in use, due to the conditions under which they must operate and this acidity will give some indication of the point at which they will begin to form objectionable emulsions in the presence of water.

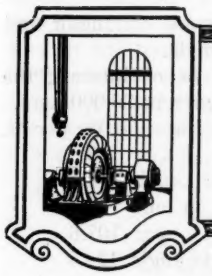
Specifications Give Certain Limits Which Should Be Maintained

Government specifications covering oils suitable for turbines or internal combustion engines are given in the table. Flash and fire points as determined by the Cleveland open cup test should not be lower than the figures given in Col. 2 and 3, while the pour test with A. S. T. M. apparatus should not exceed the values in Col. 6. Color determinations with the Union Colorimeter should be made without the use of dilutent and the oil should not be darker than the A. S. T. M. color listed. Viscosity and carbon residue tests should be made with a Saybolt viscosimeter and Conradson tester respectively and should be within the limits shown.

In addition to the above acidity, corrosion and emulsion tests are called for. Not more than 0.10 mg. of potassium hydroxide shall be required to neutralize one gram of the oil and a clean copper strip submerged in the oil for 3 hr. at 212 deg. should show no discoloration. Emulsion tests for light and medium oils are made at 130 deg. and for heavy oils at 180 deg. Demulsibility should not be less than 300 and the oil should separate; which means only a slight cuff with no continuous layer of emulsion between the water and oil, in 30 min. from an emulsion with a. distilled water, b. one per cent salt solution, c. normal caustic solution.

*Reprinted from Oil Power, published by the Standard Oil Company.

According to a report in the VDI-Nachrichten for Mar. 16, Bopp & Reuther, Mannheim, Germany, has built a Venturi Meter of 2300 mm. (7 ft. 7 in.) inside diameter for the new hydro-electric station Achensee in Tyrol. It is equipped with an electrically operated long distance indicator and is one of the largest water meters ever built for volumes to 90,000 cu. meter (2,377,530 gal.) per hr.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Calculation of Forces Due to Short Circuits*

SHORT CIRCUITS ON ALTERNATING CURRENT CIRCUITS GIVE RISE TO FORCES OF LARGE MAGNITUDE. BY W. F. SUTHERLAND

WHENEVER CURRENT is passed through a conductor, mechanical stresses are set up in it and in the means employed for supporting it in space. These stresses may be due to the proximity of magnetic materials or, more usually, to the effect of adjacent conductors carrying current. Bends and changes in direction also have their effect on the stresses set up in the conductors. In an ordinary circuit with current flowing out in one conductor and back in the other, the forces set up are those of repulsion. On the other hand, if a group of conductors carry current in the same direction as in a bus-bar composed of several strips of copper, forces are set up tending to bring the conductors closer together.

The magnitude of these forces thus created is ordinarily far too small to cause any concern, but under short-circuit conditions where large amounts of power are available, great care has been taken in the design of nearly every piece of apparatus through which the power flows to limit the stresses as far as possible to reasonable values and to make adequate provision for such forces as are likely to be encountered.

The force for simple conductors, i. e., straight and of comparatively small cross-section with respect to the spacing, is fairly easily calculated from fundamental principles and without going too deeply into theory it may be stated that for direct current flowing in two parallel wires, the following equation holds good.

$$F = \frac{5.3978 I^2 10^{-7}}{A} \quad \ldots\ldots\ldots (1)$$

where

A = distance between conductors in inches
F = force in lb. per ft. run of conductor
I = current in amperes.

As an example consider two busses 12 in. apart and carrying a current of 20,000 amp. The force exerted for direct current will work out to about 18 lb. per foot run.

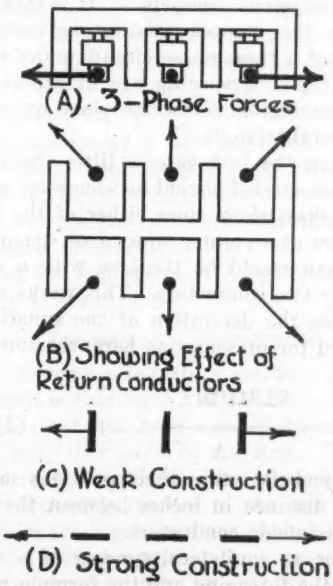
The preceding formula also gives the average force found in a circuit carrying single-phase alternating current. This average value is very much lower than the maximum value which can be obtained as will be seen from the following.

Any force exerted by alternating current is of a pulsating nature, passing through a zero value twice in every cycle, when the current is zero, and reaching a maximum value also twice in every cycle when the current wave is passing through its peak value. The average value of this pulsating force is given by equation (1) if the current is expressed in r.m.s. (root mean square) amperes as is usually the case. It is interesting to note that the r.m.s. ampere not only gives the same heating effect as direct current but also the same average force of repulsion or attraction.

BUSSES MUST BE CAPABLE OF WITHSTANDING MAXIMUM FORCES

We are not greatly interested, however, in the average value of any force since the bus supports and other mechanical structures have to withstand the maximum instantaneous force likely to be exerted. This is something altogether different and at first glance seems to be surprisingly large. Let us see how an expression for it can be derived.

Assume that our short-circuit current has been obtained in r.m.s. amperes as would usually be the case. The peak amperes or the maximum instantaneous value



TYPICAL INSTALLATIONS OF CONDUCTORS SHOWING THE DIRECTION OF FORCES ON THE CONDUCTORS DUE TO SHORT CIRCUIT CURRENTS

*This is the last of a series of three articles on the engineering problems due to short circuit currents on power systems. The first appeared on page 681 of the June 15 issue, and the second on page 782 of the July 15 issue.

which the current will have, assuming a sine wave, can be obtained by multiplying the r.m.s. value by $\sqrt{2}$. Since the expression for force involves the square of the amperes flowing, the maximum force will be just twice that of the average force, thus giving a constant of $5.3978 \times 2 = 10.7956$.

This, however, is not the whole story since under certain conditions the force may rise to four times this latter value. In the first of this series of articles on page 683 of the June 15 issue, in Fig. 5 were shown two types of short-circuit current curves, one symmetrical about the zero axis, resulting from a short-circuit at the time of generator peak voltage, and one totally displaced above the zero axis, resulting from a short circuit when the generator voltage is passing through its zero value. This latter current wave, while initially partaking of the character of a pulsating direct current, having no negative value, rapidly swings down below the zero axis and assumes the usual character of an alternating current wave. Either type of current wave may be expected or any value in between, depending on the instantaneous value of the voltage at the instant of short-circuit.

The maximum value of the asymmetrical or displaced current wave can be twice that of the symmetrical wave as an upper limit. This must be allowed for, and since the force is proportional to the square of the current, a multiplier of 4 must be introduced into our equation, thus making the constant $10.7958 \times 4 = 43.12$. The equation for a single-phase short circuit then becomes

$$F = \frac{43.12 I^2 10^{-7}}{A} \quad \ldots\ldots\ldots\ldots (2)$$

where the symbols have the same significance as before and where the current is expressed in r.m.s. amperes.

Short circuit troubles may be due to faults to ground or between phases. Trouble, no matter how started, frequently ends up in a three-phase short owing to the proximity of adjacent conductors. It is thus of interest to determine the stresses existing between the three bus-bars say of a three-phase circuit under these conditions. Two types of spacing are in general employed either with conductors all in one plane or at the apices of an equilateral triangle.

Considering the first case, a little study will show that the forces exerted should be somewhat smaller than for a single-phase short since either of the two outside conductors are at a greater equivalent spacing from the other two than would be the case with a single-phase short on only two conductors. This works out in practice and while the derivation of the equation is somewhat involved for presentation here, the end result is of interest:

$$F = \frac{32.34 I^2 10^{-7}}{A} \quad \ldots\ldots\ldots\ldots (3)$$

where the symbols retain their previous meaning and "A" is the distance in inches between the center and either of the outside conductors.

Forces for an equilateral spacing of conductors are higher than the foregoing and the formula works out to

$$F = \frac{37.36 I^2 10^{-7}}{A} \quad \ldots\ldots\ldots\ldots (4)$$

where "A" is the distance between one conductor and the next along the side of the triangle.

The following comparison may be of interest, the distance "A" being 12 in. and the current 20,000 amp.

	Force in lb. per ft.
Direct current short circuit	18
Single-phase short circuit	144
Three-phase short circuit, busses in one plane	107.6
Three-phase short circuit, busses in triangle	124.5

This table demonstrates in striking fashion the vast difference between direct and alternating current under short circuit conditions.

The formulas just given enable one to approximate the forces likely to be encountered and values obtained from them may be used in designing equipment for power station uses. The remainder of the problem resolves itself into one of mechanical design and in this another interesting feature must be taken care of—impact.

Mechanical Analogy of Short Circuit Condition

A loaded beam is under a state of stress, the lower fibres being in tension, the upper ones in compression. Now if a load is suspended say by a string so that no weight is borne by the beam, no stresses will be developed in it until the string is cut. At this instant, however, the resulting fibre stress will rise to a high value, in fact to twice the value given by a quiescent load. While this impact load, as it is termed, is only of a momentary nature it must be allowed for. Since short-circuit stresses are usually considered as instantaneous in the nature of their application, a factor for impact is usually incorporated in the design of equipment. For instance, assume a bus supported every 4 ft. 6 in., carrying 20,000 single-phase short-circuit amperes and spaced at 12 in. from its neighbor. The short-circuit will develop $144 \times 4.5 = 747$ lb. on each support. This is high enough in itself, but when impact is considered, the designer has to allow for a load of $747 \times 2 = 1494$ lb. A factor of safety of at least two should also be included, making the required strength of the support $1494 \times 2 = 2988$ lb., a requirement of respectable magnitude.

It will be noticed, of course, that the stresses rise as the square of the current; this being so, low tension equipment should be of much greater mechanical strength than where high voltages are employed. It is fortunate in some ways that this is so, since the requirements of high voltage flash-over and high mechanical strength are mutually incompatible.

Concerning the design of supporting structures, a few remarks may not be out of place. The accompanying figure shows typical installations of conductors. In (A) three conductors are installed in a structure, all in one plane. The two outer leads are subjected to the greatest force on a three-phase short-circuit; theoretically the center one will be in a state of equilibrium between the other two. In (b) another set of leads has been added at the rear of the former three, a condition encountered if conductors are looped up through a structure to provide space for disconnecting switches, current transformers, etc. The resulting forces have been materially increased.

The center leads are now subjected to forces caused

by their mutual interaction while the outer leads not only have the same force acting on them as before, but also an additional component, resulting from the proximity of the rear conductors. Where such circuit arrangements are employed, it is well to remember that the stresses on supports and copper work rise to high values.

In "c" three bus bars are shown, the flat copper lying in parallel planes. Such an arrangement is weak mechanically and from this standpoint has as much to commend it as would be found in laying the floor joints of a house flat-wise instead of on edge. The better arrangement is shown in "d" where the copper lies all in the same plane. Assuming one bar of 3 by ¼-in. copper in each case this last construction has twelve times the strength of the former.

Bus Protection in Generating Stations

SINCE THE BUS IS THE MAIN THOROUGHFARE FOR ALL CURRENT, PROPER PROTECTIVE SCHEMES ARE OF GREAT IMPORTANCE

AMONG THE VARIOUS forms of electrical conductor carrying electric current from the point of generation to the load or point of application none are so important as those known as the bus bars or busses. The bus is the common thoroughfare, the neck of the bottle, in fact, through which all generated current must pass on its way to the motors or lamps or heaters in which it is used. It is highly necessary therefore to maintain the busses in an operative condition and all possible precautions must be taken to guard against their failure.

Bus failure may occur in various ways; it may result from electrical breakdown of insulation, from an arc over due to conducting material on surface of insulation, from mechanical breaking of insulation, from arcing due to the opening of a disconnecting device carrying current or from accidental contact. There are other causes of failure but these are most common.

Bus protection may be regarded in two ways, first from a mechanical or structural standpoint and second from an electrical standpoint. The first method has to do with the general features of construction and depends largely upon the size, voltage and character of the service on which the bus is used.

At first busses were built by simply running cables on wooden racks. As the capacity increased cables gave way to copper bars, rigidly supported on structural steel or iron pipe framework. This method is still used in most direct-current work and on low voltage alternating-current service, but with high voltage alternating currents, the hazards introduced by such open construction are too great and the busses are placed in compartments, giving what is known as the cellular type of construction.

This cellular type of construction gives excellent protection from accidental contact or from short circuits due to introduction of foreign articles such as tools, cleaning equipment, etc., but it is difficult to build this type of structure so as to prevent the ionized gases due to a primary failure from causing a secondary failure. In speaking of failures we may class a secondary failure as one due to the fact that some other (a primary failure) failure has preceded it.

It was with the idea of eliminating secondary failures from ionized gases due to primary failures that the isolated phase construction was evolved. With this type of construction the phases are spaced at relatively great distances, each being placed in a separate room.

With still a different idea in mind the armor clad or compound-filled equipment was developed. There each phase conductor is covered with insulation and the three run together in a closed metallic conduit which is filled with insulating compound. The latter is intended primarily to keep air and moisture completely away from the insulation on the cables.

ELECTRICAL PROTECTION

In all the preceding methods of bus protection the idea has been largely to prevent secondary failure. Primary failure in all cases has been accepted as possible. On large systems, however, the consequences of a primary failure are often so severe that everything possible must be done to avoid or minimize the effects of primary failure. This must be accomplished by electrical means.

Obviously the perfect protective system would function an instant before the actual failure took place. As no device has been developed which can anticipate a failure, it is necessary to employ devices which shall act as quickly as possible and isolate the bus at the first sign of failure.

In considering bus protection, it is usual not to include under this heading, the overcurrent and directional relays ordinarily used on the feeder circuits, since these relays automatically remove faulty feeders from the main bus before serious trouble develops. The generators too are usually provided with differential protection but in case of a bus short circuit these would not protect the generators and the bus and the results might be extremely damaging. In such cases, in addition to differential protection, overcurrent protection on the generators is also provided. Such protection, if provided, should be set for operation only under extreme short circuit conditions and only after a considerable time, preferably longer than the time allowed on the feeders connected to the bus. With such an arrangement the generators will be disconnected from the bus only as a last resort.

DIFFERENTIAL PROTECTION

One of the most satisfactory methods of bus protection developed is that known differential protection, the same scheme that has been applied so successfully to generators and other parts of a system. With this system the current transformers on corresponding phases of all leads bringing current to the bus and all leads outgoing from the bus have their secondaries connected in parallel, in such a way that the current from all the incoming transformers flows into all the outgoing transformers. The system operates upon Kirchhoff's law, that the sum of all the currents flowing to a junction

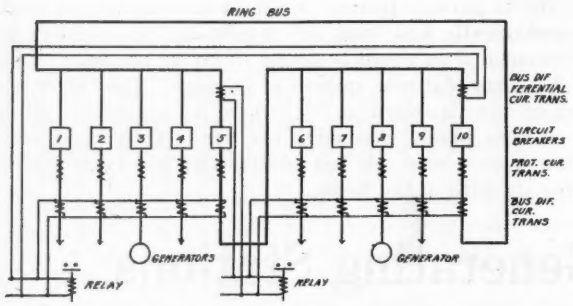


FIG. 1. SINGLE LINE DIAGRAM OF A RING BUS EQUIPPED WITH DIFFERENTIAL PROTECTION

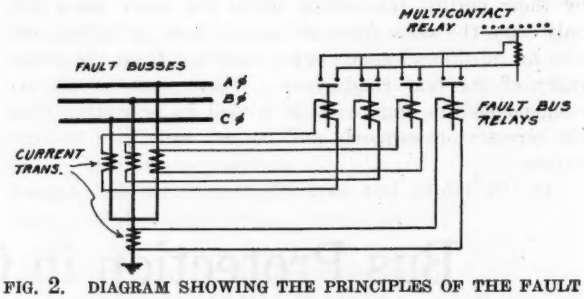


FIG. 2. DIAGRAM SHOWING THE PRINCIPLES OF THE FAULT BUS RELAY SYSTEM

point must be equal to zero. The bus in this case is the junction point in question and since the sum of the currents in the primaries of the current transformers must equal zero, the secondary currents must also equal zero. If now, a ground or short circuit occurs on the bus, an extra path is established which is not equipped with a current transformer, and the sum of the current transformer primary currents is no longer zero. Neither can the secondary currents equal zero and a current relatively equal to that flowing through the fault path will flow in the secondary circuit which can be made to operate a relay which in turn will open all the oil circuit breakers connected to the faulty bus section.

Two protective schemes of this kind may be made to overlap each other. If two bus sections are joined by an oil circuit breaker and the current transformer on one side is connected into the protective scheme of the other side, then the breaker is included in the protection of both sides and an insulation break down may be made to clear both bus sections. A diagram of such a system described in the General Electric Review for May, 1926, is shown in Fig. 1.

Fault Bus Protection

Another scheme of bus protection devised is that known as the fault bus system. This system was fully described in the General Electric Review in May, 1926, but for the purpose of showing the principle a brief description will be here presented. The proposal to use this system resulted from the practice, common in electrical stations, of connecting to ground all the metallic parts in the bus switchgear but separated from line potential by insulation. This is done to provide a low resistance path to ground for the fault current.

It can readily be seen, therefore, that if the ground connections from the various pieces of apparatus are grouped together and a relay placed in the path to ground, the fault current can be made, through this relay, to isolate the faulty section of the bus. In practice this is accomplished by installing a fault bus to which the grounds of the various switches and bus structures are connected.

To protect against a single failure from line to ground, the fault busses of each phase of a bus section may be joined together and a single current transformer put in the conection between the junction and ground. The fault bus relay is connected to the secondary of this transformer. The relay is an instantaneous overload relay, hand reset and if desired can be made to close a number of tripping circuits through an auxiliary multi-contact relay.

Often, however, single phase line to line faults may occur as two simultaneous line to ground failures and in this case very little current would flow through the current transformer in the ground lead. To obtain isolation of the bus under this condition additional current transformers should be installed in each of the leads from the fault busses in each of the three phases before they are joined as shown in Fig. 2. The relays in the secondary circuits of the latter current transformers are similar to the fault bus relay and should have their contacts connected in parallel with its contacts as shown.

Phase Balancing Scheme

A scheme of protection that makes use of the fact that bus short circuits are practically never balanced and also that the short circuit current is greater than that which would be obtained under any other condition, is the phase balancing scheme of protection. Two kinds of relays are available for this application. In one the currents in the two phases oppose each other tending to produce relay rotation in opposite directions. When unbalance occurs the relay operates. The other type relay is what is known as a phase sequence relay in which a potential balance is maintained by a balanced 3-phase current.

This arrangement is of advantage only where occasional balanced overcurrents are of such magnitude as to prevent using overcurrent relays. It makes a good discrimination between balanced currents and short circuit currents and protects against both single-phase short circuit and ground. Either of the types of relays used can be set so high that no short circuit on a feeder can affect it.

Its disadvantage is that there is danger that external unbalancing will affect currents that are expected to be balanced. It therefore is not adapted to loads that may normally become unbalanced.

Of the various systems of bus protection described in this article, the differential system is perhaps the most popular. It has a number of advantages which may be enumerated as follows: It can be made an integral part of a uniform differential scheme, protecting the entire system. Short time settings clear bus short circuits rapidly, and prevent spreading the disturbance, besides reducing the damage to the local circuit. Differential settings can be made for much smaller disturbances than overcurrent settings. There is no need of close comparison of feeder and bus protection to avoid false operation; and no danger that on a very severe short circuit on the line the relay will operate.

A Modern Rubber Glove Testing Equipment

APPARATUS USED BY EASTERN COMPANY FOR TESTING LINEMEN'S GLOVES MAY BE EASILY MADE. BY VERNON W. PALEN

NOTHING IS MORE essential in the prevention of accidents in the maintenance of distribution systems than a thoroughly reliable means of testing the rubber gloves worn by the lineman. A rubber glove with a weak spot in it is worse than no glove at all. The practical glove testing apparatus shown in the accompanying illustrations was developed and is being used by a large eastern electric company.

The equipment was constructed of more or less standard material and is intended for testing gloves on a comparatively large scale. It is fool proof and can be operated by one man. A description of this equipment is given here so that other companies having need for similar equipment may use the ideas incorporated in its design. As may be seen from the illustrations, the apparatus occupies a floor space approximately 11 ft. square and is entirely screened in by grill work so as to prevent anybody from coming in contact with the high voltage parts. A control panel is placed on the outside of the grill so that the equipment may be operated with perfect safety to the operator; in fact, the set cannot be operated unless the door is closed.

No attempt will be made here to list the various parts used in the construction of the set. Standard pipe, angle and fittings are used and the design can be varied to suit individual requirements. A wiring diagram is presented, however, to show the electrical connections and the procedure followed in operating the set. Electrical equipment required for this installation is listed as follows:

1—Transformer, single phase, 2½ kw., 11,500-230/110 v.
1—Potential transformer, 13,200/110 v. with fuses.
1—Voltage regulator, 1 kv.a., 110/220 v., 9.1/4.55 amp.
1—Sign lighting transformer, 250 w., 10 or 20 v. secondary.
1—Voltmeter, a.c. 0-12 kilovolts.
1—Ammeter, a.c. 0-30 milliamperes.
1—Minibreaker, 110 v., 4 amp.
1—Clock.

Pilot lamps, switches, push buttons, etc.

The electrical contact to the inside and outside of the glove is made by means of water, the glove being filled with water and then immersed bodily into a water tank.

In actual use, the operating procedure is as follows:

The tanks 1, 2, 3, 4, 5, 6 are filled to about four inches of the top using ordinary hydrant water. This is accomplished by opening the valve marked "supply" on Elevation B-B. The rubber gloves to be tested are attached over the collars shown in Fig. 2 which hold them. The overflow petcocks are left open. The valve supplying water on each glove is opened but due to the pressure of the water it is well not to have them fully

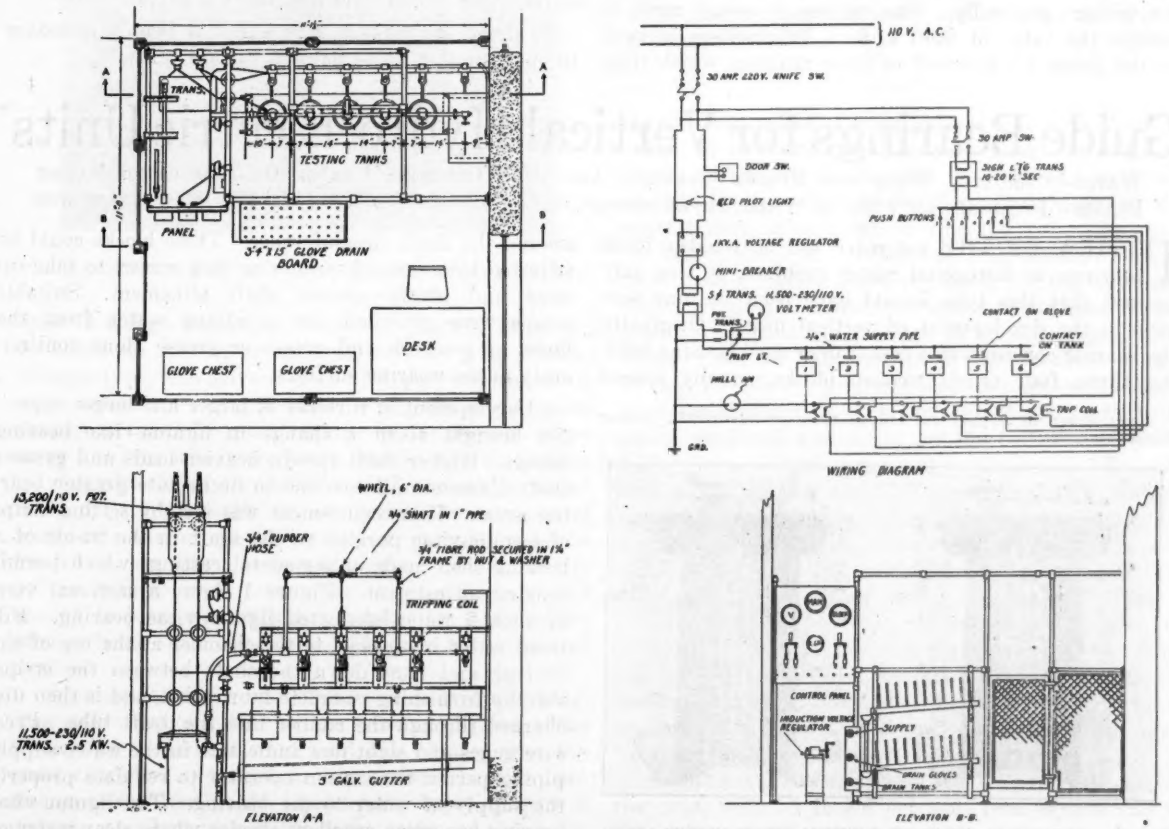


FIG. 1. PLAN, ELEVATION AND WIRING DIAGRAM OF GLOVE TESTING SET

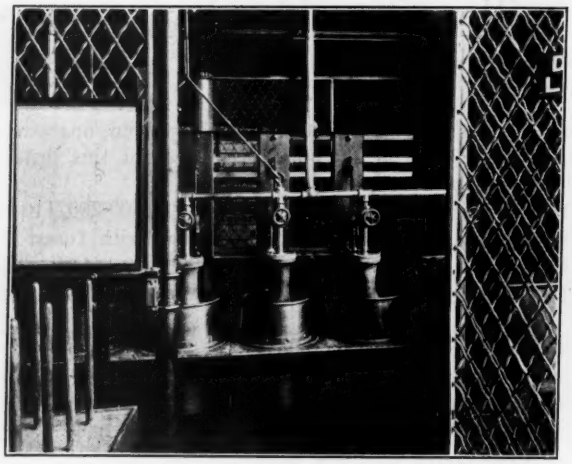


FIG. 2. CLOSE-UP VIEW, SHOWING RUBBER GLOVES IN POSITION

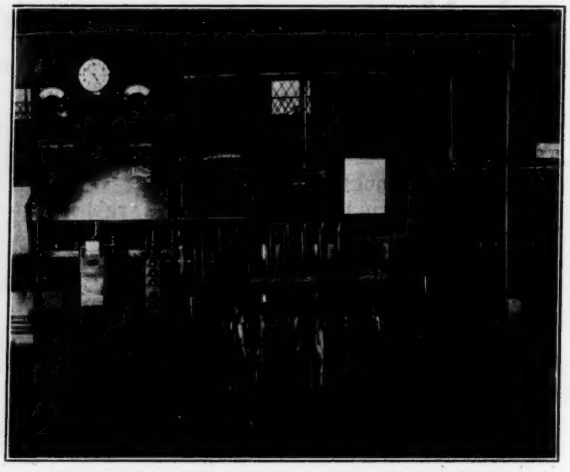


FIG. 3. GENERAL VIEW SHOWING CONTROL PANEL

open but to have them "cracked." Water is then admitted to the glove by opening the main water valve marked "supply" on Elevation B-B.

When each glove has been filled with a suitable amount of water the overflow petcocks as well as the main water valve are closed. The operator then steps outside of the high voltage enclosure, closing the door, which is equipped with an automatic device, so that the machine may not be operated unless this door is closed.

The operator then starts to apply the test voltage by means of the induction regulator which brings up the voltage gradually. The voltage is raised until it reaches the value of 6600 v. a.c. This voltage is held on the gloves for a period of three minutes, which time period may be measured on the clock mounted on the control panel. After the voltage has been held on the glove for three minutes, the operator reads the milliampere leakage on each glove. This is done by means of the push-buttons 1, 2, 3, 4, etc., on the wiring diagram which throw each individual glove into the milliammeter circuit. If the leakage on any glove exceeds ten milliamperes, the glove is rejected.

After the test is completed the water in the gloves may be syphoned into the waste pipe by opening all the valves, leaving the overflow petcocks and the main water valve closed, and opening the syphon valve.

To drain the tanks 1, 2, 3, 4, 5, 6 it is only necessary to open another valve marked "drain tanks."

Guide Bearings for Vertical Hydro-Electric Units*

WATER-LUBRICATED WOOD AND RUBBER BEARINGS ARE MOST COMMON; USE OF OIL-LUBRICATED BABBIT BEARING INCREASES ON TURBINE WHILE IMPROVEMENTS IN ITS DESIGN ARE MADE FOR USE WITH GENERATOR

IN VIEW OF THE extensive use of wooden block bearings in horizontal water turbines, it was only natural that this type should have been the one first used in the development of vertical units. Originally the bearing consisted of a cast-iron or steel housing holding three, four or six wooden blocks, equally spaced around the shaft circumference. These blocks could be adjusted by means of wedges or jack screws to take up wear and obtain correct shaft alinement. Suitable means were provided for supplying water from the flume or pensteck and grease or grease alone continuously to the wearing surfaces.

*Abstract of report for June, 1927, of Hydraulic Power Committee, N. E. L. A.

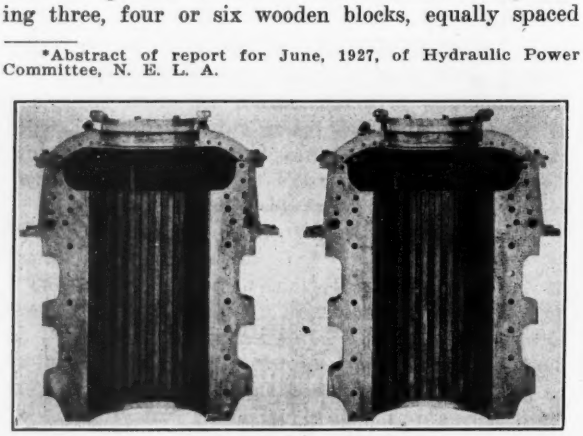


FIG. 1. SECTIONAL VIEW OF LIGNUM-VITAE WATER-LUBRICATED BEARING

Development of turbines of larger and larger capacities brought about a change in lignum-vitae bearing design. Higher shaft speeds, heavier loads and greater shaft diameters all combine to necessitate greater bearing areas. This requirement was met by setting strips of lignum-vitae parallel to the shaft in the inside of a bearing shell made of segmental castings which permit bearing adjustment. Figure 1 shows a sectional view of such a water-lubricated lignum-vitae bearing. Filtered water is supplied to the chamber at the top of the bearing and runs down the shaft between the strips, thereby furnishing complete lubrication, and is then discharged through the runner into the draft tube. Pressure gages and sight flow indicators in the water supply piping permit the station operator to regulate properly the supply of water to the bearing. The lignum-vitae bearing has given excellent service where clear water or water containing only silt has been available. Close

running and complicated runner seals on large diameter, high capacity turbines and gritty water, however, have led to the adoption in some cases of oil-lubricated, babbited bearings.

There is nothing unusual in this type of bearing, as the oil is supplied to it through ample grooves cut in the babbit. Thermometers with high temperature alarms are placed in the oil supply lines or directly in the babbit; sight flow indicators and electrically operated no-flow alarms keep the operator fully informed as to the oil supply. Figure 2 shows the assembly of an oil-lubricated bearing. Cooling coils are sometimes placed in the larger of these bearings, where radiation from the bearing housing alone would not be sufficient to dissipate the heat generated.

Several Types of Bearing Pumps Used

Where the station has not been equipped with a central oil system, several types of individual pumping units, arranged to start pumping as soon as the turbine revolves, have been used. These pumps have been developed to a high degree of reliability. Briefly, they can be listed as follows: gear type, belt or gear driven; plunger type, cam driven; viscosity type, revolving drum and stationary shoe; flexible type, chain or spiral spring operated by main turbine shaft; pressure type, sump revolves with main shaft, supply pipe stationary.

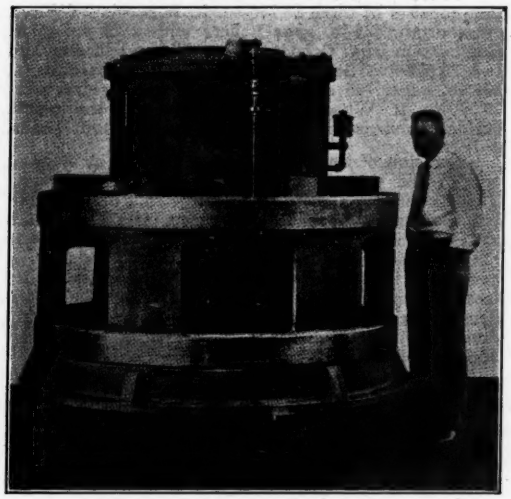


FIG. 2. ASSEMBLY OF AN OIL-LUBRICATED STEADY BEARING

Possibly one of the drawbacks of the oil-lubricated bearing is the difficulty of preventing the entrance of water into the oil, as the bearing of necessity must be located as low down as possible, which means directly on the turbine head cover. Raising the bearing just enough to place a stuffing box around the shaft in the turbine head cover effectually eliminates this source of trouble.

A comparatively recent development in guide bearings makes use of rubber as the wearing element. The lubricating medium is water and it is claimed that the same care does not need to be exercised to eliminate grit as is required in the lignum-vitae type. Figure 3 gives an excellent idea of the construction of this bearing and the type of grooves provided for the proper circulation of the lubricating water.

Since the recent development of high capacity, single runner units with small runner clearances, the importance and necessity of strong and rigid bearings has become a question of prime importance.

Generator Steady Bearings

It is apparent that generator designers have not used the wide variety of types of steady bearings which have been installed in turbines. The type of steady bearing almost universally used for the generator is of the oil-lubricated type having a babbited wearing surface. At present an effort is being made to make these bearings more oil tight to prevent the escape of oil and oil vapor and designs are being arranged to prevent the incoming air for generator cooling from coming in contact with the bearing housings. A modification of the present Kingsbury thrust bearing may offer possibilities as a combined thrust and guide bearing, where it is highly desirable to obtain and maintain small clearances between the stationary and rotating parts of the generator or turbine.

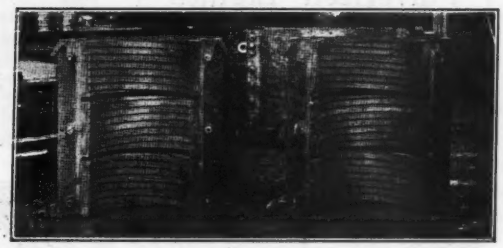


FIG. 3. VULCANIZED RUBBER STEADY BEARING

Combination of a gas producer and vertical tubular boiler of Cochran type has been tested out with coke breeze containing 17 per cent moisture and heat value of 9950 B.t.u. as fired at the Hyde Park Depot of Manchester Corp. Elec. Dept. in England.

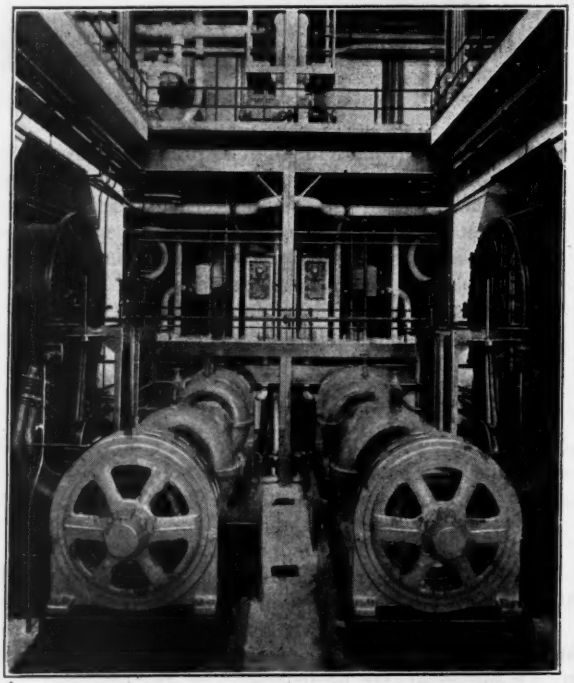
The producer is a cylindrical brick chamber with air-cooled walls, located below the boiler fire box and coaled through a central chute from above. Gas passes through holes in the producer roof and is burned with a bunsen flame effect, air being heated by the producer walls to 74 deg. F. Air for producer and for burners is supplied by a fan which took 0.74 per cent of the power in the steam produced and steam for the producer was some 5.5 per cent of that generated by the boiler. Evaporation was at the rate of 8.22 lb. from and at 212 deg. per pound of fuel, pressure being 55.4 lb. and feed temperature at 108.5 deg. F. This referred to coal of good quality, 14,000 B.t.u., would be equivalent to 9.93 lb. from and at 212 deg.

Allowing for producer steam and fan power, the efficiency was 73.84 per cent but flue gas temperature was high, 577 deg. F., as is common with vertical tubular boilers, and it was estimated that addition of an economizer would raise the thermal efficiency of the plant by from 5 to 6 per cent.

Combustion was smokeless and CO_2 ran 15.7 to 17.5 per cent, with 2.1 to 3.6 per cent free oxygen and no CO in the gases.

Further tests are to be made at the fuel research station at Greenwich.

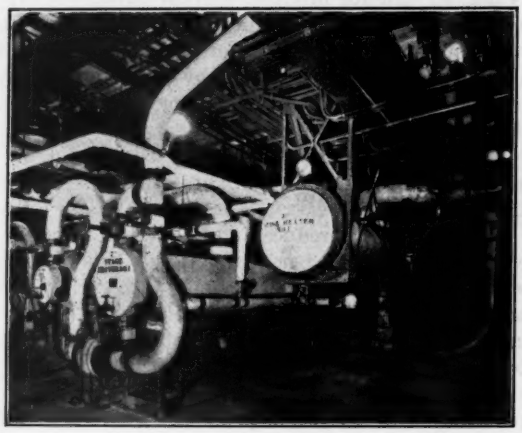
Trinidad Station of the Texas Power & Light Co. Burns Pulverized Lignite

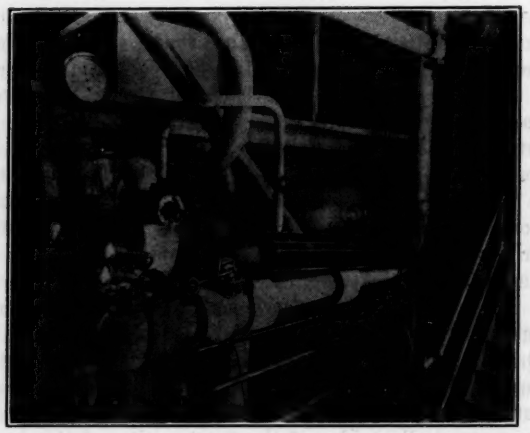


TRINIDAD STATION of the Texas Power & Light Co. is located on the Trinity River between Ft. Worth and Dallas. The initial installation consists of three 18,756-sq. ft. Babcock & Wilcox cross drum, 425-lb. gage boilers with 2520 sq. ft. of Combustion Eng. Corp.'s water walls and screens and two 20,000-kw. General Electric turbines operating at 375 lb. gage, 700 deg. F. The turbines are set over 20,000-sq. ft. Wheeler Cond. & Eng. Co. single-pass surface condensers with tubes rolled in both heads.

Expansion of the tubes is taken care of by floating one of the tube sheets upon a rubber diaphragm. These condensers were the first of this design built, but the same type have since been installed in both the Stanton and Ft. Lauderdale stations. Careful tests have demonstrated the effectiveness of this type of condenser in preventing contamination of the boiler feed system by circulating water leakage. Each condenser has two 20,000-g.p.m. motor-driven circulating pumps, two motor-driven hotwell pumps, external air coolers and twin steam jet air ejectors.

Texas lignite with a high moisture and ash content is burned in pulverized form. Steam is extracted from three stages of the turbines for feed heating and the make up is supplied by two double effect high-pressure evaporators. Condensate from the main condenser is pumped through the inter- and after-condensers of the ejector, the low pressure stage heater and the intermediate stage heater to an open daerating heater. From this heater it flows to the boiler feed pumps to be pumped through the evaporator condenser and high-pressure stage heater to the boiler.





Forcing Production in Ice Plants

A Discussion of Various Factors Involved in Forcing Refrigerating Equipment to Secure High Capacity. By Charles H. Herter

IN AN ICE PLANT to which the writer's attention was directed several months ago, considerable trouble was had with cracked ice. This was a 500-t. ammonia ice machine installation with 3 electric-driven compressors, two 15 by 15-in. machines and four 19 by 19-in. units. The suction pressure carried was 20 or 21 lb. and the head pressure 200 to 220 lb. The tank temperature normally was around 18 to 19 deg. sometimes as low as 16 deg.

In attempting to determine the reason for the large amount of cracked ice several questions presented themselves. Why was there so much cracked ice in the summer when the tanks were at 17 deg.? Was the back pressure carried the most economical? What difference did one degree drop in tank temperature make upon the capacity of the tank per 24 hr.?

The freezing time was from 42 to 38 hr. Dump water, used to dip the cans, usually had a temperature of 70 deg. Cans used were of the drop tube type and about 22 to 26 lb. air pressure was used with 70 deg. water for the needles to remove the tube out of a 300-lb. block of ice. The back pressure often went to 18 lb.

This presented quite an interesting problem and, since the questions involved are of interest to all refrigerating men, the following discussion may not be out of place here.

The difficulties met with in this plant were doubtless due to the fact that the owners demanded the maximum output that could possibly be produced with the equipment provided. They had about 7200 cans with about 14 cans per ton. Normally, the economical rating with 300-lb. cans is 16 cans per ton. On this basis the capacity of this plant was 7200 ÷ 16 or 450 tons of ice per 24 hr. Since it takes 6-2/3 300-lb. cakes to make 2000 lb. the freezing time with 16 cans is 16 ÷ 6-2/3 × 24 = 57.6 hr.

Rule for Freezing Time

A fairly close rule for the freezing time of can ice (regardless of can water temperature) may be stated as follows:

$$\frac{7 \times \text{avrge. thickness of cake ice in in., squared}}{32 - \text{brine temperature deg. F.}} = \text{hours}$$

The cakes being 11½ in. thick at the top, 10½ in. at the bottom, a mean thickness of 11 in., in this case we may write

$$\frac{7 \times 11^2}{32 - 17.3 \text{ deg. brine}} = \frac{847}{14.7} = 57.6 \text{ hr.}$$

showing that a brine temperature of 17.3 deg. F. would suffice when producing ice at the rate of 450 t. per 24 hr.

It is not likely that the ice cracked at this brine temperature. Ice usually cracks because the brine is 14 deg. and colder, in which case the freezing time is of course shortened also. Under normal conditions cracking of ice is to be expected when the freezing time is 44 hr. or less. This condition corresponds to 44/24 × 6-2/3 = 12.225 cans per ton, so that the output with 7200 cans would be 7200 ÷ 12.225 = 589 tons. Undoubtedly this production was aimed at, because the compressor capacity is adequate, and freezing times of 42 and 38 hr. were used.

The summer brine temperature range maintained, namely 19 to 16 deg. F., is not consistent with a short freezing time, because with 44 hr., using above formula, it cannot be higher than 12.74 deg.:

$$\frac{847}{32 - 12.74} = 44 \text{ hr.}$$

Low Suction Pressure Unavoidable

When a plant is thus being forced during the few summer months, the maximum economy cannot be attained, because the ammonia evaporating temperature must necessarily be low enough to abstract the heat from the brine with the existing amount of coil surface. Upon inquiry it was found that there are eight freezing banks, each with 17,180 ft. of 1¼-in. pipe (coils 8 pipes high), total coilage 137,440 ft., which, divided by 2.301, equals 59,700 sq. ft. exterior coil surface. As the water is probably forecooled in summer, to say 40 deg., the work of the bank coils does not exceed 1.4 per ton of ice, or total 589 × 1.4 = 824.6 tons refrigerating effect. If at such time the suction gage pressure is 18 lb., the corresponding saturation temperature within the coils should be 3 deg., the difference between brine and ammonia being 12.74 — 3 = 9.74 deg. Thus the coefficient of heat transfer k, for the coils would be

$$\frac{824.6 \text{ tons} \times 12{,}000 \text{ B.t.u. per hr.}}{59{,}700 \text{ sq. ft.} \times 9.74 \text{ deg. diff.}} = 17 \text{ B.t.u.}$$

With 20-lb. suction pressure and 5.5 deg. vapor, the difference becomes only 12.74 — 5.5 or 7.24 deg., giving a value of k of 22.9 B.t.u., which is very good for coils 859 ft. long.

Unbalanced Plant Justified

While suction pressures of 25 to 30 lb. are much more economical than 20 lb., the pressure must be kept so low whenever the production is to be forced. As this high rate of production is demanded during but three or four months of the year, it is commercially more advantageous to install ample machine capacity for this peak load than to provide only enough compressor capacity for say 450 t. ice, even though in the former case the kilowatt-hours per ton ice will be higher. During the balance of the year the reduced output, such as 300 tons, can be made as economically as in any other plant if care is taken to elevate the evaporating pressure as much as possible.

In the foregoing, I have tried to show the intimate relation between output and necessary back pressure. In any case that back pressure is the proper one which allows of producing the desired quantity of ice with the least difference in temperature between brine and vapor.

Suppose that during August 360 tons of ice are to be made every 24 hr., using 7 ice tanks with 6300 cans. Then, cans per ton ice = 6300 ÷ 360 = 17.5, and the freezing time, 17.5 ÷ 6-2/3 × 24 = 63 hr. The brine

temperature will have to be 32 — (847 ÷ 63) = 18.55 deg. F. The heat to be abstracted from the coils using 50-deg. can water is 360 × 1.45 = 522 t. refrigeration. Taking k = 20 B.t.u. per sq. ft. per hr. per deg. difference, this difference will be

$$\frac{522 \times 12{,}000}{59{,}700 \times \frac{7}{8} \times 20} = 5.99 \text{ say } 6 \text{ deg.}$$

Hence the vapor temperature should be at least 18.55 — 6 or 12.55 deg. F., which corresponds to an evaporating or back pressure of 26 lb. If we assume k = 17 B.t.u. only, the difference becomes 20 × 5.99 ÷ 17 = 7.05 and the vapor temperature 18.55 — 7.05 = 11.5 deg., corresponding to 25 lb. If at this time, the suction pressure actually carried is below 25 lb. gage, the plant is not operating at best economy. Also, if this back pressure cannot be held it indicates a shortage of ammonia.

Preventing Cracking of Ice

To minimize cracking of low temperature ice the block must be exposed to temperature changes as gradually as possible. To secure as long a time as possible per 3-can lift, harvesting should be done at strictly uniform rate each hour out of 24. The thawing water should be as cold as possible, which can be obtained by changing water as sparingly as possible in the thaw tanks. During the act of thawing, the water (not the can) should be agitated as much as possible, introducing compressed air if necessary. For the thawing needle nothing, but cool water should be used and necessary time allowed to free the air tube which is frozen in. The high pressure air tube blowing air at an angle down into the can subjects the cake to greater temperature strain while thawing than the tube which is fastened permanently to the can for example in the corner, because there it affects the block no more than does any portion of the sidewall of can and dispenses with the use of the thawing needle.

The methods indicated are believed to be more effective than to let the frozen cans stand in the open to temper. The latter method hardly is possible in a large plant because of lack of time and space and because of extra handling required.

Newport Co. Burns Pulverized Pitch

AT THE PLANT of the Newport Co., Carrollville, Wis., the use of pitch as fuel for the boiler furnaces has recently aroused considerable interest. This boiler plant, as reported by Heat Engineering, contains six 402-hp. Stirling boilers designed for 200 lb. pressure, with Foster superheaters to provide 100 deg. superheat. Boilers were originally fired with stokers, but last year three of the furnaces were remodeled and Aero pulverizers installed to supply them with fuel.

The fuel burned is coal or tar pitch, a by-product from asphalt manufacture, depending upon the market prices prevailing. Records show that the pulverizers carry the boiler rating up to 200 per cent.

This pitch has a melting point of between 260 deg. and 280 deg. but the operators have found that the pulverizers handle it without trouble. Of course, when burning pitch, water-cooled burners are necessary, otherwise the pitch may soften before leaving the burner. Variable speed control is used to drive the feed mechanism of the pulverizers to provide maximum flexibility. It is stated that one pulverizer has handled 5500 t. of fuel without replacing of parts and another more than 2700 t. in 5 mo. without opening the casing of the machine.

Under average conditions, furnace temperature is about 2700 deg., the CO_2 about 14 per cent, the furnace draft about 0.1 in. and the stack temperature about 540 deg. at 175 per cent of boiler rating. Heat value of the pitch is about 16,135 B.t.u. per lb. and the weight of ash and refuse has been found to be less than 0.33

PULVERIZERS SUPPLYING PULVERIZED PITCH THROUGH WATER-COOLED BURNERS TO THREE 402-HP. WATER-TUBE BOILERS

per cent. Ash is cleaned out of the furnaces about once every three months. Typical analysis of this pitch is as follows, the amounts all being in per cent: Proximate analysis—moisture 0.00, volatile 49.33, ash, 0.29, fixed carbon 50.38. Ultimate analysis: carbon 93.71, hydrogen 4.00, oxygen 0.65, nitrogen 0.98, sulphur 0.44.

Evaporation per pound of pitch as fired is stated to be 11.2 lb. of water.

Plant Losses Survey

EVERY industrial organization has, as its prime purpose, to serve customers and receive a profit. Losses either in production or in power increase the cost of service and reduce profits. To get information which will assist in giving service and increasing profits is the real reason for a survey and the use of graphic instruments. Methods and possible results are given in a bulletin on this subject by the Esterline-Angus Co.

Instruments are needed for measuring power used at various points and purchase of portable instruments is recommended at the start, putting in permanent equipment where the survey shows it to be desirable. Instruments needed will depend on the size and character of the plant but a wattmeter, suited for the kind of current used and with current and voltage transformers for alternating current work, shunts and re-

sistances for direct current work, so as to cover the range of voltages and loads to be measured is essential. For alternating current systems, a voltmeter is also needed, in order to determine power factor.

In making a survey, don't decide in advance what you expect to find. Be on the lookout for new, unexpected information and make notes on the records of conditions existing when they are taken. Then study the records to see what they show.

Power is an element of cost and it pays to be economical of it. Losses from motors running idle, or underloaded so as to produce low power factor and waste power are expensive. The reasons should be sought and load redistributed so that economical operation is secured. Records should be made for each motor when idle and when loaded and for power used by each piece of equipment when in good operating condition. These will serve as standards of comparison when making later records. Shafts out of line, bad bearings and settling of foundations may increase power losses largely. It is one function of a survey to detect these losses and remove the causes.

Breakdowns are frequently caused by operating at an overload, which condition may not become apparent except by a survey or test which will enable the remedy to be applied before breakdown occurs, thus saving expense in shutdowns and repairs. Graphic instruments should be kept at work gathering information and the tales told of poor efficiency should result in action. Detailed information of hourly, daily and weekly conditions will often show where machines are being used ineffectively, where loads can be moved off peak to reduce the charges on purchased power, where workmen are slow in starting work and anticipate the hour of stopping. Reduction of power cost, increase of productive effort and expense of upkeep can thus be accomplished and, when the right points for permanent instruments are determined, their records may become an incentive to competition as to who shall show the best results in output.

Thorough initial survey to find out all possible facts about the power generated and where and how it is expended, study to determine how better operation may be effected and regular checking up to make certain that such operation is maintained will amply repay the expense and work required for such survey.

Boilers at Riverside Station Show Good Results

COMPLETE TESTS ON A BOILER UNIT EQUIPPED WITH AN AIR PREHEATER USING STEAM BLED FROM THE MAIN TURBINE FOR PREHEATING AIR FOR COMBUSTION

COMPLETE TESTS on a 1044-hp. Heine boiler 15 rows high operating at 400 lb. per sq. in. pressure were recently made at the Riverside station of the United Light and Power Co. The superheater is the Foster divided type with 2910 sq. ft. of convection superheater surface located in the top of the first and second passes and 89 sq. ft. of radiant superheater surface located in the rear wall of the boiler. The boiler is fired by a Taylor 10 retort, 33 tuyere hydraulic stoker, with a 2-roll clinker grinder. The projected grate area is 272 sq. ft. A 61.5-sq. ft. Foster water bank located in the rear wall of the ash hopper is connected into the circulatory system of the boiler.

In the air duct between the forced draft fan and the stoker is a steam heated air preheater with 2010 sq. ft. of heating surface. Steam for use in the air preheater is bled from the second stage of the turbine. After leaving the first pass of the boiler, the gas passes through a Foster single-pass counterflow economizer with a heating area of 6488 sq. ft. located in the main flue between the boiler and induced draft fan.

Throughout the tests Franklin County, Illinois bituminous screenings with an average moisture of 10.97 per cent was used. The heat content was 11,511 B.t.u. per lb. as fired or on a dry basis 12,924. The proximate analysis showing 55.88 per cent fixed carbon, 33.10 per cent volatile matter and 11.02 per cent ash. The sulphur content was determined separately and averaged 1.73 per cent.

Efficiency of the boiler, water back and superheater plotted against the rating is shown in Fig. 1. If the economizer is included the efficiencies are higher than shown on Fig. 1 ranging from 82 per cent at 300 per cent rating to 86 per cent at 150 per cent rating. The efficiency with steam preheated air seems to be identical with the efficiency without the preheater. In calculating the efficiency with steam preheated air the boiler is charged with the heat furnished by the preheater, since this heat is received from an outside source. In plotting the curves of efficiency, the calculated efficiency is increased or decreased by an amount equal to the difference between the unaccounted for loss by the heat balance and 2.9 per cent, the average unaccounted for loss of all tests throughout the series. The use of steam preheated air apparently makes no difference in the efficiency of the unit if the unit is charged with the heat added through the preheated air.

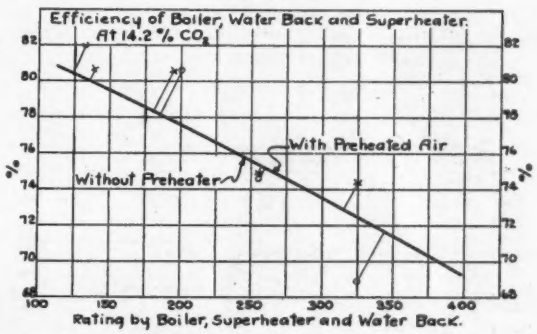


FIG. 1. BOILER EFFICIENCY WITH STEAM HEATED PREHEATED AIR DIFFERS LITTLE FROM THE EFFICIENCY WITHOUT THE PREHEATER IF THE STEAM USED IN THE HEATER IS CHARGED AGAINST THE BOILER

Plotted as a function of the CO_2 in the flue gas leaving the boiler at 192 per cent rating, the efficiency was found to be 77.8 per cent at 14 per cent CO_2 drop-

*From The Safety Valve, published by Heine Boiler Co.

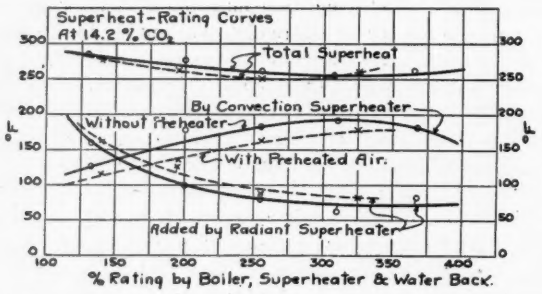


FIG. 2. CONVECTION AND RADIANT SUPERHEATERS ARE USED IN SERIES TO GIVE A NEARLY CONSTANT TOTAL SUPERHEAT

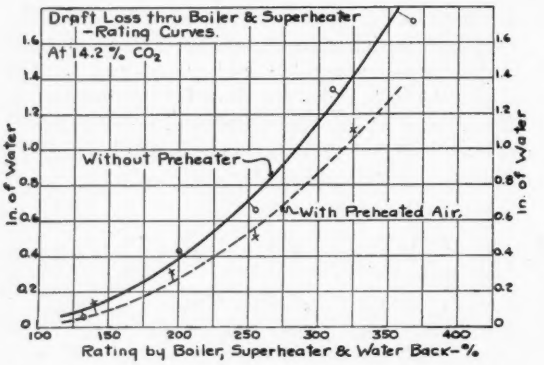


FIG. 3. PREHEATED AIR SHOWS A MARKED DECREASE IN DRAFT LOSS THROUGH THE BOILER

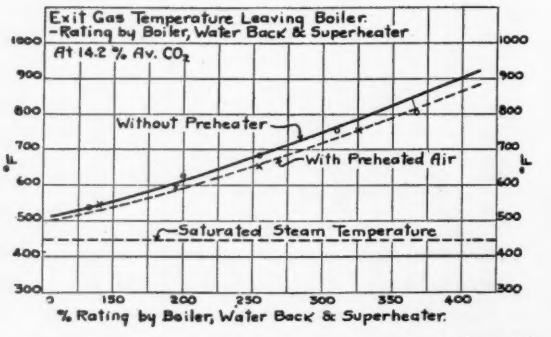

Exit Gas Temperature Leaving Boiler.
-Rating by Boiler, Water Back & Superheater
At 14.2 % Av. CO_2
Without Preheater
With Preheated Air
Saturated Steam Temperature
°F
% Rating by Boiler, Water Back & Superheater.

FIG. 4. PREHEATED AIR LOWERS THE EXIT GAS TEMPERATURE LEAVING THE BOILER ABOUT 40 DEG. AT 400 PER CENT RATING

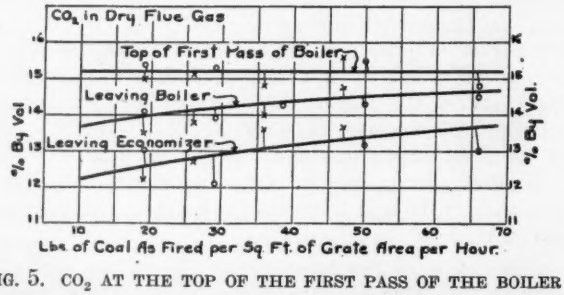

CO_2 in Dry Flue Gas
Top of First Pass of Boiler
Leaving Boiler
Leaving Economizer
% By Vol.
Lbs. of Coal As Fired per Sq Ft. of Grate Area per Hour.

FIG. 5. CO_2 AT THE TOP OF THE FIRST PASS OF THE BOILER REMAINS APPROXIMATELY CONSTANT AT 15.2 PER CENT AT ALL RATES OF FIRING

ping to 75.7 per cent at 12 per cent CO_2 and 75.3 per cent at 10 per cent CO_2. Moisture in the steam leaving the boiler was found to be quite low, amounted to 0.85 per cent at 150 per cent rating, increased to 1 per cent at 250 per cent rating and to 1.5 per cent at 400 per cent rating.

Curves in Fig. 2 show superheat from different parts of the superheater plotted against the rating of the boiler superheater and water back. The total superheat remains remarkably constant, the maximum variation being only approximately 45 deg. between 150 and 400 per cent rating. Variations of the superheat with preheated air is shown on the same figure by the dotted line. The effect of the preheater is to decrease the amount of superheat by the convection superheater and to increase the amount of superheat by the radiant superheater, giving a very slight change in the total superheat. The characteristic curves with and without preheated air are approximately the same, however.

Draft loss through the boiler and superheater at 14.2 CO_2 is shown on Fig. 3 both with and without preheated air. The effect of preheated air is to decrease the draft loss by an amount equal to approximately 0.06 in. of water at 150 per cent rating and 0.44 in. of water at 350 per cent rating. Without preheated air the draft loss through the economizer at 150 per cent of rating amounts to approximately .95 in. of water and this increases very nearly as the square of the rating to 4.60 in. of water at 400 per cent rating. This gives a total draft loss through the whole unit, consisting of boilers, superheaters and economizers of 1.10 in. at 150 per cent rating and 6.40 in. of water at 400 per cent rating.

Exit gas temperatures leaving the boiler are shown plotted against the boiler rating in Fig. 4. With preheated air at 150 per cent rating and 14.2 per cent CO_2, the exit gas temperature is 555 deg. or approximately 110 deg. above the saturated steam temperature. At 400 per cent rating the exit gas temperature is 905 deg. or approximately 460 deg. above the saturated steam temperature. The effect of preheated air is to lower the exit gas temperature leaving the boiler approximately 15 deg. at 150 per cent rating, 25 deg. at 250 per cent rating and 40 deg. at 400 per cent rating.

Preheated air slightly decreases the temperature of the gas entering the economizer, as shown in Fig. 4, but the temperature of the gases leaving the economizer is practically the same with and without preheated air. The effect of the preheat on the water leaving the economizer is to lower the temperature by a small amount somewhere between 5 and 10 deg. The temperature of the gases leaving the economizer at 150 per cent rating amounts to approximately 270 deg. and increases to approximately 415 deg. at 400 per cent rating.

When burning 20 lb. of coal per sq. ft. of grate area, the CO_2 at the top of the first pass was 15.2 per cent as shown by Fig. 5. This value remains practically constant up to the maximum of 66 lb. of coal burned per sq. ft. of grate area per hr. At 20 lb. of coal per sq. ft. of grate area per hr. the combustible in the ash was approximately 13 per cent. This increased nearly as a straight line to 40 lb. of coal per sq. 42 per cent combustible at 66 lb. of coal per sq. ft. of grate area per hr.

Boiler Water Tests Should Be Utilized---II*

WATER ANALYSIS FORMS THE BASIS OF METHODS OF CHECKING LEAKY BLOW-OFF VALVES OR BROKEN BAFFLES AND DETERMINING THE SCALE REMOVAL OR FORMATION WHILE THE BOILER IS IN OPERATION. BY CHARLES E. JOOST†

IT IS COMMON practice for plants using treatment through softening systems to test the boiler water for alkalinity and salt. In these determinations two readings are made: one the phenolphthalein alkalinity reading and the other the methyl orange alkalinity reading. To most engineers the significance of these two readings is not clear, therefore a word of explanation is not amiss at this time.

In treating any water either through a lime-soda system or a zeolite system, because of temperature and pressure, the soda ash entering the boiler with the feed water is partially broken down to caustic soda according to the following reaction:

$$Na_2CO_3 + H_2O = 2NaOH + CO_2$$

soda ash + water = caustic soda + carbon dioxide

To illustrate how this reaction takes place in the boiler just being fired up, Fig. 1 has been prepared. Before this boiler was placed in operation 50 lb. of soda ash

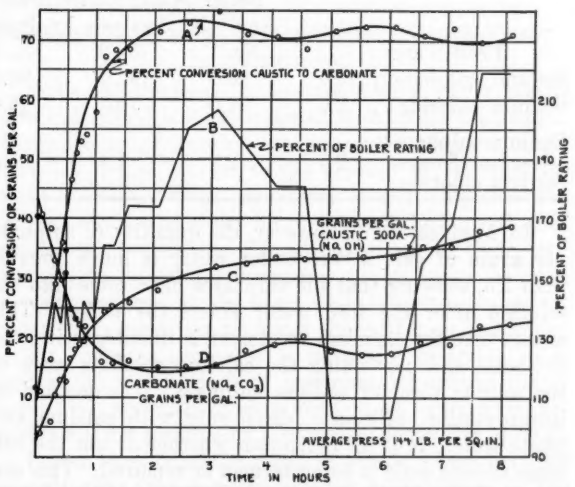

PERCENT CONVERSION CAUSTIC TO CARBONATE
PERCENT OF BOILER RATING
GRAINS PER GAL. CAUSTIC SODA (NaOH)
CARBONATE (Na2CO3) GRAINS PER GAL.
AVERAGE PRESS 149 LB. PER SQ. IN.
PERCENT CONVERSION OR GRAINS PER GAL.
PERCENT OF BOILER RATING
TIME IN HOURS

FIG. 1. SODA ASH ENTERING WITH THE FEED WATER IS PARTIALLY BROKEN DOWN TO CAUSTIC SODA AND CARBON DIOXIDE

was placed in the drum in order to bring about a relatively high initial alkalinity. It will be noticed that as the boiler is being put under pressure the soda ash disintegrates and it completes its maximum conversion after the boiler has been in operation about two hours.

Figure 2 illustrates the amount of conversion of soda ash to caustic soda that takes place in boilers operating under 282 lb. pressure. This data was taken at a plant using jet condensers. Almost 100 per cent makeup was softened through a hot process system. A comparison of Fig. 1 and Fig. 2 shows the effect of pressure on the conversion of soda ash to caustic soda within steam boilers.

Phenolphthalein and methyl orange readings give a means of determining the amount of soda ash and caustic soda when they are present together. For concentrated boiler waters, the phenolphthalein reading will indicate all of the caustic soda alkalinity plus one-half of the soda ash alkalinity while the methyl orange reading will indicate the sum of the soda ash and caustic soda alkalinities. By subtracting the phenolphthalein reading from the methyl orange reading and multiplying by two, the result is the amount of sodium carbonate in solution.

To convert this into grains per gallon, consideration must be given to the normality of the acid used. If

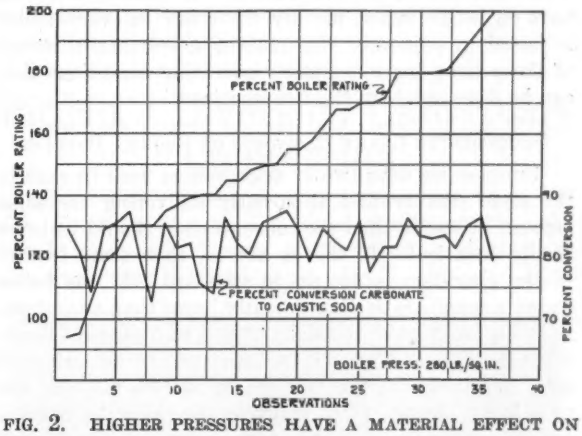


FIG. 2. HIGHER PRESSURES HAVE A MATERIAL EFFECT ON INCREASING THE CONVERSION OF CARBONATE TO CAUSTIC

100 c.c. of water was used initially with twentieth normal acid, the soda ash reading for titration should be multiplied by 1.5 to give the amount of soda ash in grains per gallon. To determine the caustic soda it is only necessary to subtract the calculated soda ash from the methyl orange reading and if this result is multiplied by 1.13, the result will be in grains per gallon caustic soda. A simple calculation illustrating the mathematical procedure is given in Table I.

TABLE I. CAUSTIC SODA CALCULATIONS CAN BE MADE FROM THE RESULTS OF THE ALKALINITY TEST

C.C. 1/20 Normal Acid—100 C.C. Sample	
Methyl orange reading	30.0
Phenolphthalein reading	25.0
Difference	5.0

5 multiplied by 2 equals 10 soda ash.
10 multiplied by 1.5 equals 15 gr. per gal. of soda ash.
30 minus 15 equals 15 caustic soda.
15 multiplied by 1.13 equals 16.96 gr. per gal. of caustic soda.

It is easy, therefore, to determine by this simple titration the amount of alkaline sodas in solution and their relation to each other.

Since the concentration of salts in solution has a direct bearing on the tendency to prime, the salt concentration then is a guide for blowing down and fre-

†With Cochrane Corp., Philadelphia, Pa.
*Second part of an article dealing with the practical application of simple boiler water tests.

quently engineers have by experience determined the concentration which is safe for their steaming units to carry without priming.

If a daily check on the total solid content of the boiler water is desired, it is only necessary to make periodic evaporation tests of the filtered boiler water, determining the relationship between the total solids and the salt, and apply this relationship to the daily test for salt.

As an illustration suppose the total solid content of the filtered boiler concentrate is 250 gr. per gal. and the sodium chloride or salt concentration is 25 gr. per gal., then the factor or the total solids per grain of salt would be 10 and this factor multiplied by any other sodium chloride reading would give the corresponding total solid content of this sample. In making titration tests on boiler water, usually the water in every boiler is tested in sequence. By making a systematic record of these tests, there are many operating conditions that can be discovered by their comparison.

Determining Leaky Blowoffs or Broken Baffles

Suppose we have two or more boilers fired in exactly the same manner and apparently delivering the same amount of steam, then the concentration should be practically identical. If this is not so, then some feature of the operation is not up to standard. If one boiler shows a concentration consistently lower than the others, it is apparent that we might expect an unusual operating condition and one or two reasons can be advanced as a cause. First, the low concentrations may be due to a leaky blowoff valve which could easily be checked up by noting by touch the temperature of the blowoff pipe beyond the blowoff valves. Second, water may not have been evaporated at the same rate per pound of coal as in the other units in which case we might look for broken boiler baffles. This could be checked by noting the flue gas temperature as compared to the other units.

The second condition would be indicated immediately by flow meter records on individual boilers but in cases where flow devices are not in service the chemical tests serve as an excellent check on this phase of boiler operation and has proven successful when applied to numerous boiler plants.

Determining Scale Removal and Formation

Where chemical treatment is first placed into operation or where it has been in operation for some time, information is frequently wanted as to the efficiency of this chemical treatment, whatever it may be. Ordinarily we would say that we cannot tell until the boiler is taken down for inspection. Naturally we will all agree that this is the best way for by this method there is no doubt but what the efficiency of the chemical treatment is made manifest. There are other methods, however, by which we can determine the efficiency of the chemical treatment if we will take the time to analyze samples of the feed water and of the boiler water. This can be illustrated to advantage by citing a typical illustration.

In making a determination of this character, it will be necessary to make more complete chemical tests than those described above. For this purpose it is suggested that the feed water and the boiler water be tested not only for salt but also for sulphates and that these sulphates be calculated to a common basis, let us say for instance, sodium sulphate, and the ratio of sodium sulphate to salt be calculated.

Data in Table II show figures that will give three possible interpretations to these analyses. For instance, if in the feed water the amount of sulphates calculated in terms of sodium sulphate per grain of salt is 2.5, we would expect the same ratio to exist in the boiler if no scale formation or disintegration was taking place. This is indicated under Analysis No. 1. Such a condition indicates that the water going to the boiler is softened, that the boiler originally was clean, no scale was carried down and no new scale was formed. But suppose as in Analysis No. 2 of the concentrated boiler water, analysis indicates a lower quantity of sulphate per grain of salt than the feed water, such a ratio means that the sulphate radical is going out of solution in the boiler water with the formation of calcium sulphate scale.

TABLE II. A COMPARISON OF FEED WATER AND BOILER WATER TESTS INDICATES THE CHEMICAL REACTIONS TAKING PLACE IN THE BOILER

		Boiler Water Concentrate		
		Analysis	Analysis	Analysis
Feed Water		No. 1	No. 2	No. 3
Sodium sulphate..	5.0	90.0	90.0	90.0
Sodium chloride...	2.0	36.0	70.0	16.0
Sodium sulphate / Sodium chloride	2.5	2.5	1.3	5.6

In Analysis No. 3, however, the quantity of sulphate per grain of salt in the boiler water is much greater than 2.5, showing that the sulphates have come into the solution after the feed water enters the boiler. This means that the chemical treatment is disintegrating the old scale and converting the calcium sulphate scale to the soluble form of sodium sulphate. The method of interpretation, of course, deals only with calcium sulphate scale. It is no indication whether or not the calcium silicate scale is being formed or removed. This can be determined if similar analyses are made for silica instead of sulphate; however, since calcium sulphate scale is the most common, the above interpretation serves the greatest practical use.

Determining Soluble Calcium and Magnesium Carbonates in Treated Water

With the installation of softening systems, it is often desirable to determine the extent of the removal of calcium and magnesium salts and to determine the amount of calcium and magnesium carbonates remaining in the treated water. Ordinarily this is determined by a careful analysis for these salts which can be done only by a careful and experienced chemist. For approximate results, this is not necessary and the amount of carbonates of calcium and magnesium remaining can be calculated. Suppose the following average of all daily readings be taken from reports of operation on a hot process water softener, the figures being reported in grains per gallon:

			Boiler Water	
Ph.	M. O.	Salt	M. O.	Salt
1.4	3.0	2.5	30.0	37.50

By using the method of interpretation referred to previously, the number of concentrations can be determined. Salt in boiler water ÷ salt in feed water = concentrations, so that 37.5 ÷ 2.5 = 15 concentrations.

The alkalinity of the boiler water represents the alkalinity due to soda (soda ash and caustic soda) and small quantities of calcium and magnesium carbonates which may be neglected. The alkalinity (M. O.) of the treated water, however, is the alkalinity due to the carbonates of sodium, calcium and magnesium in which case the calcium and magnesium may make up as much as 50 per cent of the alkalinity.

Now, if we know the number of times that the feed water is concentrated, we can determine the amount of soda originally in the feed water. Thus, in the above example, the boiler water contains 30 gr. of alkaline sodium salts which is the result of 15 concentrations. Therefore, by dividing the boiler alkalinity by the concentrations, the quotient will be the alkaline sodas present in the treated water, or 2 grains. Now, our treated water titration shows the presence of 3.0 gr. of alkalinity or a difference of one grain which represents the combined quantity of calcium and magnesium carbonates in solution in the treated water.

Determining Average Steam Quality Under Priming Conditions

With the demand for cleaner steam, many plants have individual boilers equipped with steam separators. Where these separators are properly designed, their efficiency is not limited to the amount of moisture initially present. With separators of this character the boilers need not be blown down through the blowoff line; instead the boilers are allowed to prime of their own volition, the separator removing the moisture as it is carried over and at the same time insuring dry steam under every condition of water concentration and boiler rating. Such a separator is naturally desirable as it insures the maintenance of maximum concentrations of water and minimum of blowdown which is the ideal arrangement not possible by a manually controlled blowoff.

Under these conditions and in plants where priming is continuous, the average amount of moisture in the steam can be calculated by simply dividing 100 times the salt content of the feed water by the salt content of the boiler water. As an illustration, suppose the salt concentration of the feed is 1.0 gr. and of the boiler water 25 gr., then the average amount of moisture in the steam delivered from the boiler is (1.0 × 100) ÷ 25 = 4 per cent.

This simple calculation is easily proven by supposing that we evaporate 1000 gal. of water during any one time interval with the knowledge that when the maximum concentration is reached which is a condition of this calculation, as many solids leave the boiler as enter it. Under these conditions the solids entering the boilers are 1000 gal. × 1.0 gr. per gal. = 1000 gr. salt. The amount of water leaving the boiler as moisture would be 4 per cent of 1000 gal. or 40 gal., and each gallon of this moisture would contain 25 grains per gallon of salt or 40 × 25 = 1000 gr. total, which exactly equals the solids entering, proving the calculation given above.

Local conditions may lead to other opportunities of interpreting these simple tests in a more elaborate manner. The foregoing, however, gives in a brief way what may be accomplished by everyday testing under everyday practice and it is not too much to say that if these tests were consistently made and interpreted in the manner given above, they would form a basis for better control over operating conditions or additional checks on mechanical equipment now in use for determining quantities.

It must be remembered, however, that the quantitative interpretation of these results depends entirely on the accuracy of the determinations. In cases where the salt content is exceedingly low, the amount of error involved is such that the results are questionable. This objection can easily be overcome by taking a sample of water which is low in salt and concentrating to 0.1 its volume or less and then carrying the titrations on this sample and working backwards for the actual concentration in the feed water.

Pit No. 4 Diversion Dam Nears Completion

AS SHOWN in the accompanying photograph, the diversion dam at Pit No. 4 development of the Pacific Gas and Electric Co. is nearing completion. The water was diverted about May 1, 1926 and since

PIT NO. 4 DIVERSION DAM UNDER CONSTRUCTION

that time construction has proceeded rapidly. Owing to peculiar formations of the river bed at this point, the construction of the dam involved unusual engineering problems. Since bed rock appears practically at the ground surface on the right bank of the river, dropping to a depth of about 50 ft. at the left edge of the river channel, the dam was designed as a composite structure. This has a heavy overpour gravity section from the left edge of the channel to the right abutment and a lighter, non-overpour struction at the left side. This composite structure, then, which rises 60 ft. above the stream bed and is 400 ft. in length, merely consists of two dams placed end to end.

The portion on the right bank is built on solid bedrock and that at the left bank on a reinforced concrete slab laid over a broad, firm earth base with concrete cutoff walls extending below the stream bed to intercept possible seepage. Extending from the upstream toe of this slab, a heavily reinforced concrete facing is carried up on a slope of ½ to 1, receiving support at the rear from concrete buttresses on 18-ft. centers.

Between the two sections of the dam a diversion wall placed on solid rock, extends 170 ft. up and down stream. This wall is 30 ft. thick at the base and 120 ft. high and serves as an artificial abutment for the overpour section and as a protective and retaining wall for the river edge of the hollow-type dam.

Just up stream from the dam at the right bank of the river, a reinforced concrete intake structure, similar to that installed at the head of Pit 3 tunnel, was built along with the first 200 ft. of tunnel.

With 2000 acre-feet of storage between this dam and Pit 3 power house the irregular flow from Pit 3 will be absorbed into this reservoir and, in turn, diverted into Pit 4 tunnel, when Pit 4 power plant is built.

One Hundred Years

A Century of Accomplishment in the Use of Graphite. By Floyd W. Parsons

IT IS something to command respect, a hundred years of steady growth and expansion. During this century of existence of the Joseph Dixon Crucible Co., have come the modern steamship, the railroad, the telephone, the electric light, automobiles, aeroplanes and the radio.

Joseph Dixon started in business when many held to the notion that nothing should ever be done the first time. The press was dead set against the introduction of gas for illumination as it might encourage late retiring and frighten horses. One state taxed bathtubs $30 a year. Joshua Coppersmith was jailed for trying to interest people in a device to transmit the human voice over wires and a woman in Providence was arrested for going without a petticoat.

To establish a business that will live and grow throughout a century requires a peculiar type of mind. The urge to pioneer, courage and the vision which enables one to concentrate all his energy behind an idea,—also the ability to doubt. Joseph Dixon was a leader in science, invention and chemistry, therefore he was a doubter. His was a restless, questioning brain. His first invention was a machine for cutting files. Then, turning to printing,—to make his type and wood engravings, he soon became skilled in wood carving. Later, experimenting in the melting of metals for type, his interest was aroused in developing a crucible capable of withstanding the heats required in such work and thus was started, in Salem, Mass., in 1827 the business of making articles from graphite.

From that day until the present, the company's growth and development have centered around this same raw material, graphite or "black lead." Mr. Dixon discovered this material on a New Hampshire farm but, realizing that this supply did not assure either quantity or quality, he arranged with sea captains to bring him a small tonnage from Ceylon.

Graphite is almost pure carbon, classified as one of the softest substances, while its brother of the same chemical nature, the diamond, is one of the hardest. A product of intense heat, graphite will withstand intense heat, hence the Dixon crucibles gave metallurgists a container that could have the contents melted in a high heat and poured time and again without disintegration. Durability and softness are qualities which have served in the making of paints and lubricants with graphite base, also in dynamo brushes, resistance rods and pipe joint compounds. Smooth surfaces for castings, sharp outlines for electrotypes and low resistance in dry cell batteries are other benefits from this versatile substance. Finally, what would happen, if we were suddenly deprived of all lead pencils, which are made, not of lead but of graphite?

In 1869, the company was deprived of the personality of its founder by his death but so wisely had he built in creating a policy of selecting executives from those who have grown up in the company, building from within, that the organization has continued self-contained and self-operating. That's why the human element problem has largely taken care of itself.

Under the guidance of E. F. C. Young as president and John A. Walker as treasurer the business went forward to a nationally recognized industry and when Mr. Young passed away in 1908, George T. Smith succeeded to the presidency. During his administration, the heart has played a most important part and consideration of the human side of the business has been prominent. As an instance, when a woman worker was ill, the superintendent asked the president how long he might keep her on the pay roll. The answer was, "Until she is well. And, John, make sure that she is receiving the proper medical attention." That's why Mr. Smith is known as "a man with a heart."

Possessed of unusual energy and of a keen and versatile mind, J. H. Schermerhorn, the vice-president, is able to visualize the future without getting out of step with the present. Ready at all times to approve of outlays that will insure the future position of the company, he is mindful of the need of keeping current activities in proper relation to current income.

Closing its hundredth year, the company had no bonded debt, no bills payable and not a single unpaid current bill. But greater than financial strength, in its promise for the future, is its unqualified acceptance of the principle that scientific research is a function of industry equal in importance to manufacturing. The search for new devices, methods, materials and uses is never ending and each bit of new knowledge developed in one department immediately becomes available for use in all other departments.

The Joseph Dixon Crucible Co. starts its second century free of moss and stripped for action. In business and life, today, we must be ready and waiting for the next development. Remember the dictum of the wise scholars on the knowledge of the ages. "This too will change," is the attitude of the company and its executives after growing wise under a century of amazing change.

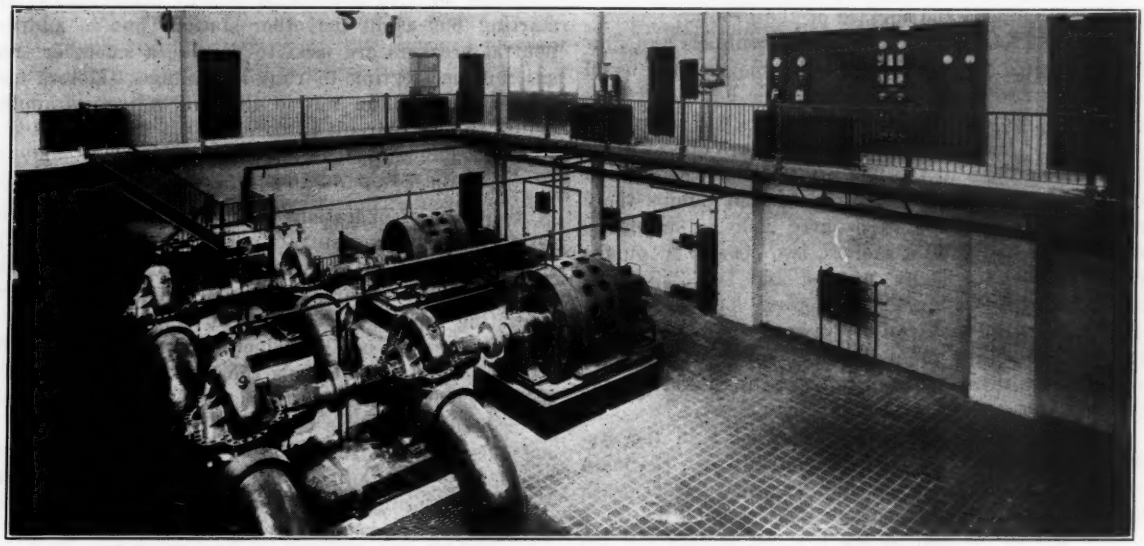
De Pauw University, located at Greencastle, Ind., recently completed a new boiler room to take care of their heating load through the winter. The main building is 25 by 57 ft. and contains one 422-hp. Stirling boiler, fired by an Illinois stoker.

Coal will be received by motor trucks and stored in covered storage to be reclaimed as needed. After crushing in a small roll crusher, it will be fed by a pan conveyor to the elevator and delivered to an overhead bunker. Ash removed from boiler by hand will be discharged by the same elevator into a small hopper to be discharged directly into trucks.

Features of Kansas City's New Pumping Plant

NEW ELEVEN MILLION DOLLAR WATER WORKS, ENTIRELY ELECTRICALLY OPERATED, ONE OF THE MOST MODERN OF ITS KIND. BY ALBERT L. MAILLARD*

IN THE APPROACHING completion of the new Kansas City water works a dream of over a decade is about to be realized. These new works complete an intake, three pumping stations, complete purification works, two pressure tunnels, a 54-in. pipe line, a 42-in. discharge main and an equalizing reservoir. All the main pumping equipment in the three stations was furnished by the DeLaval Steam Turbine Co. while all the electrical equipment including switchboards, switching equipment, motors and outdoor substation was furnished by the Westinghouse Electric and Manufacturing Co.



EAST BOTTOMS PUMPING STATION AT KANSAS CITY

Two 24,000,000 gal. per day pumps driven by 2000-hp. motors. Ultimately six pumps will be installed in this station

The intake is located on the harbor line of the Missouri River and is founded on 70-ft. timber piles. About 100 ft. north of the shore line is located the low lift pumping station, the function of which is to pump the raw water from the intake up to the purification works located some 1200 ft. north. The water is pumped to the preliminary settling basins from which point it flows by gravity through the various processes of dosing with chemicals, mixing, coagulating, final settling and filtering, finally reaching the clear water basin which is beneath the filters.

In the low lift station the pumps are double suction, single stage, volute pumps with side suction and discharge. Four pumps are installed at present but provisions have been made for a fifth. Each of three of the pumps has a rating of approximately 35 million gallons per day (m.g.d.) at 40 ft. head. At maximum head of 48 ft. the capacity of each is 32 m.g.d. The fourth pump is designed with similar characteristics but for the present it is equipped with a 20-m.g.d. impeller. Each pump has its separate suction line from the intake, the suction nozzles being 36 in. in diameter, and the discharge 30 in.

Each pump in the low lift station is driven by a 400-hp. unity power factor, synchronous motor operating at 2300 v., 3 phase, 60 cycle, 360 r.p.m. The excitation for these moters is supplied by two 30-kw. motor generator sets. The control for this electrical equipment comprises a 14-panel switchboard mounted on the gallery floor, 34 ft. above the pump room floor. A mechaniical remote control system operates the oil circuit breakers which are located on another gallery 10 ft. below the switchboard floor. The main bus is sectionalized by two oil circuit breakers and in the section between these breakers a station service feeder is connected which serves the power, lighting and heating transformers. Each outside section of the bus is fed by an incoming feeder, each feeder having the capacity of the entire station. One section serves two motors while the other serves the remaining two motors and the future unit. Motor starting is accomplished by means of compensators and a starting bus. This bus is sectionalized by disconnecting switches each section being served by a compensator.

Auxiliary power for operating vacuum pumps, sump pumps, motor generator sets, crane and gate valves in this building as well as the revolving screens in the intake is obtained from 2300/230-v. transformers.

Both the intake and low lift stations are heated electrically and are served by a 150-kv.a., 3-phase, 2300/230-v. transformer. Industrial oven type, 220-v. ribbon element heaters, locally controlled, suitably backed with reflecting and insulating material and provided with grille work in the front are placed along the gallery.

It was stated previously that the water was pumped from the low lift station to the purification works, finally reaching the clear water basin. Adjoining this

*Consulting Engineer.

basin is the secondary pumping station the function of which is to pump the water through the main tunnel and thence through a branch tunnel and a pipe line to the reservoirs at two high pressure pumping stations. The existing high pressure station known as Turkey Creek Station is steam operated, while the new East Bottoms Station is electrically operated. The main pressure tunnel is 7 ft. 6 in. inside diameter and about 15,000 ft. long, driven in solid rock at a depth of about 350 ft. The branch tunnel to Turkey Creek Station is 6 ft. inside diameter and is about 11,000 ft. long. Like the main tunnel, it is in solid rock and is lined with concrete. This tunnel is about 150 ft. beneath the ground and has been completed. The 54-in. flow line to the East Bottoms Station is about 15,000 ft. long and is laid close to the surface of the ground.

At peak loads the friction in these tunnels and flow line is expected to be appreciable but not beyond usual standard practice. The combined static head, and friction against which the secondary pumps will operate is about 51 ft. Accordingly, these pumps are almost exact duplicates of those in the low lift station. In addition to the main pumping units and vacuum pumps there are in the secondary station three 2500-g.p.m. pumps driven by 75-hp., 2300-v. motors, two 500-g.p.m. pumps driven by 60-hp., 2300-v. motors, and two 250-g.p.m. pumps driven by 25-hp., 220-v. motors. The three 2500-g.p.m. pumps are used for supplying wash water to the filters and the other pumps are used for supplying high pressure water for hydraulically operated valves, for flushing purposes, etc., about the plant.

The switchboard comprises 21 panels and the system is that of mechanical remote control with the main breakers located in a room on the lower floor beneath the switchboard. The main bus is sectionalized in a manner similar to that at the low lift station but between the sectionalizing oil circuit breakers there are two feeders, one for power and the other for lighting. A central heating plant provides steam heat for the entire purification works.

Electric Power Furnished From an Outdoor Substation

Both low and secondary pumping stations are fed from an outdoor substation. Power is obtained from the Kansas City Power & Light Co. at 13,200 v. over two feeders one overhead and the other underground. Substation equipment includes two 2500-kv.a. banks of transformers, each transformer being rated 833 kv.a., 13,200/2300 v., single phase, 60 cycle. These capacities were chosen on the basis that when overloaded 25 per cent one bank can carry 90 per cent of the ultimate load of the two pumping stations.

The two incoming feeders form a loop and are protected by directional relays. The overhead line is provided with choke coils and oxide film arrester. Each bank of transformers is controlled by oil circuit breakers, differentially protected. A tie line breaker on the high tension side provides flexibility while the low tension side is connected to a bus which is sectionalized by disconnects. From this bus four feeders, two to each station, supply the low and secondary station.

The high pressure station known as the East Bottoms Pumping Station comprises two 24-m.g.d. pumping units with an ultimate capacity of six such units. These units are made up of two single stage, double suction, volute pumps connected in series and operating against a total head of about 390 ft. They are driven by 2000-hp., 13,200-v. synchronous motors running at 720 r.p.m.

The switchboard has 14 panels at present but will ultimately be expanded to 21. The system is electrically remote controlled. Two lines feed the station direct from the company's power house bus. Ultimately there will be four such feeders. These feeders are installed two in a duct line, each line taking a different route from the power house to the station. The main bus in the station is in duplicate but may be made a continuous bus by use of a tie breaker.

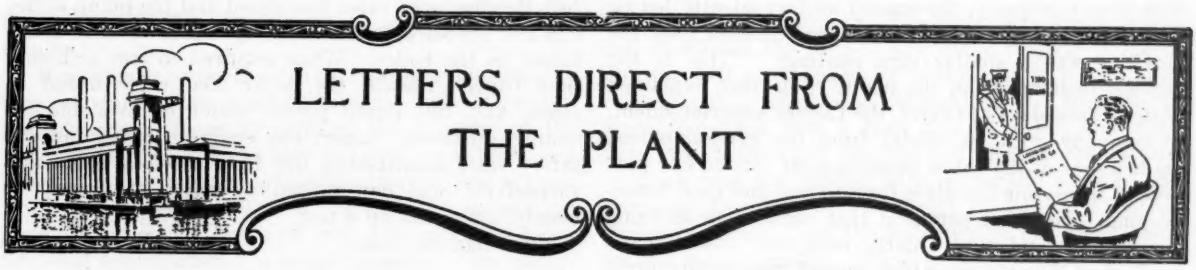
Motor starting is accomplished by compensators and starting bus as in the other stations but in addition neutral breakers are used to provide a smoother transition from starting to running voltage. Motors have 85 per cent pull in torque and full voltage is applied before the field circuit is closed.

Motor Starting Operation Is Automatic

Sequence of operations in starting a motor is interesting. First, the neutral breaker is closed manually, which automatically closes the compensator breaker. Then, the starting breaker is closed manually. An accelerating relay controls the next steps. As it closes it trips the neutral breaker which automatically closes the running breaker and trips the starting breaker. The field breaker is then closed manually and the compensator breaker likewise tripped. If the field breaker is not closed within 10 sec. after closure of the running breaker the field failure relay trips the running breaker. With the closing of the running breaker, a solenoid valve on the automatic check valve is closed.

In this station there is a 30-kw. motor generator set which performs four important functions. It can supply excitation for any one or two of the main motors. It provides a source of direct current for lighting in case of failure of the lighting transformer. It can give a full charge to the battery and provide current for the control system while the battery is being charged. Auxiliaries are fed from a bank of 13,200/230-v. transformers and lighting from a 13,200/230-115 v. transformer. Emergency lights are fed from the battery.

The automatic stop and check valves are of the Johnston type and open and close automatically with unbalance of hydraulic conditions in the valve. The necessary unbalance of hydraulic conditions may be controlled by a solenoid operated valve in the blowoff line of the main valve. The solenoid circuit is interlocked with the running breaker and a control switch on the switchboard is inserted in the circuit. With the closing of the running breaker the solenoid valve closes and permits the main valve to open as soon as the pressure on the pump side of the valve becomes greater than that on the line side. As soon as the running breaker trips out the solenoid valve opens and the main valve closes. The control switch on the board permits the operator to open the solenoid valve circuit, thereby opening the solenoid valve, which in turn closes the main valve even with the pump operating at full speed. The operation of the main valve may be noted by the pressure gage reading.



Trouble With Generator in Charging Batteries

In a plant where a motor-generator set was used for charging electric vehicles the motor generator had been giving trouble because of the charging current while carrying its load. The motor was a 3-phase, 25-cycle squirrel-cage induction type, and the generator, a 110-v., 600-amp., compound-wound machine. It was assumed that the trouble was due to incorrect brush setting or the shunt across the series fields being of improper resistance. In order to have the machine under working conditions when it was inspected by the troubleman, it was operated several hours at full load so that the temperature would be at the maximum when the test was made. Without changing the field resistance the load, which was 485 amp. at 110 v., was cut off and the voltage dropped to 85 v. This indicated that the generator was overcompounded.

The explanation of what happened is as follows: As the load had been increased, the rheostat had been adjusted so as to hold the voltage down and as the batteries had became charged their voltage increased, causing their current input to decrease. This in turn caused the total generator load to decrease and its voltage to drop until a point was reached which was less than the battery voltage, 106 v. When this occurred current passed through the series field in the reverse direction, greatly reducing the generator voltage. The voltage could be brought back to the proper value by opening the armature circuit and using one of the batteries to excite the shunt fields.

To overcome this condition, the resistance of the shunt across the series field was decreased. After several trials, virtually a flat working characteristic curve was obtained for the working range of the generator.

Woodward, Okla. Harry J. Achee.

Hot Flue Gas Used With Unit Pulverizer

Last fall the Irving-Pitt Mfg. Co. became interested in burning pulverized coal in their boiler room. After some consideration they decided to build the equipment in their shops, using the old style ball mill principle as a pulverizing medium. The boilers are 72 in. by 18 ft. h.r.t set 6 ft. 6 in. from the floor line, with a 6 ft. dutch oven in front. There is no trouble in maintaining a temperature of from 1800 to 2000 deg. F. in the combustion chamber with an uptake temperature of from 580 to 620 deg. F.

Coal is placed in the hopper A, and fed into the ball mill, B, by a screw conveyor or feeder. The ball mill contains steel balls ranging in size from 1 to 2 in. diameter, and these balls grind the coal to the required fineness. The finished product is delivered to the burner by fan C, through pipe E. The fan is driven by 2.5 hp. variable speed motor marked D on the sketch.

Primary air or gas drawn through the mill for the purpose of classification is taken from the boiler breeching and enters the ball mill at an average temperature of 465 deg. As the mixture leaves the mill at an average temperature of 120 deg., the heat given off by the gas is used to dry the fuel. The amount of gas used depends

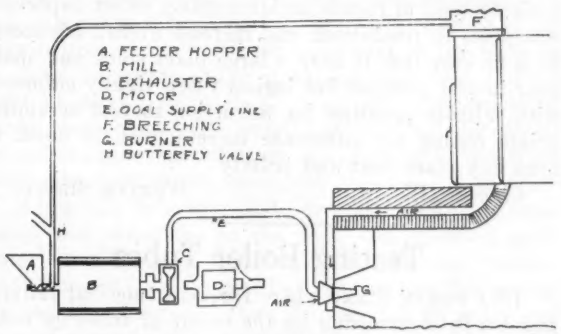


DIAGRAM SHOWING ARRANGEMENT OF EQUIPMENT

upon the moisture content of the coal. A wye connection with a butterfly valve placed in the flue gas pipe connection near the mill serves as a method of regulating the amount of flue gas used.

In developing the burner with this arrangement, it was found necessary to incorporate a mixing chamber wherein a variable amount of air at boiler room pressure and temperature enters the front of the burner and passes to the mixing chamber to be thoroughly mixed with the product of the mill. The remainder of the air is taken in the usual way around the burner.

By placing a bridge wall 14 in. high at a point 9 ft. 6 in. from the burner we found that slag was confined in the space in front of this wall. All deposit back of the wall is fly ash, easily removed with a shovel. When using 9000 lb. per 10 hr. day of Southern Kansas coal, averaging 12 per cent ash, we had 19.5 cu. ft. of slag and 96 cu. ft. of ash in our combustion chamber after a five weeks' run.

Kansas City, Mo. Frank R. Hunter.

Plant Housekeeping

While on a hasty tour of a large industrial plant in Ohio, we noted, with some amusement, a large 14-ft. sign over the door of the shipping department which read: "This is the dirtiest department in the plant." In

answer to our query, the superintendent silently led us to the assembling department where, perched over the entrance was a similar sign reading: "This is the cleanest department in the plant." He then explained that on Saturdays at twelve, the factory superintendent, in company with an official from the general offices, made a tour of the entire establishment for the sole purpose of inspecting the place for neatness and good housekeeping. To the department that showed up as being the cleanest and most orderly went the "clean" sign, while that department which proved inexcusably dirty or disorderly had the imposition of the "dirtiest department" sign for an entire week. According to the superintendent, the men of the institution found considerable pleasure in hunting out the "dirtiest department" on Monday mornings, then "riding" the men for their slovenliness throughout the remainder of the week. The idea, according to the superintendent, "works wonderfully well."

Good housekeeping is imperative in plants. Disorderliness contributes to accident hazard, costly production and low morale, while neatness and cleanliness invariably tend to reduce accident totals, effect important economies in production and increase overall efficiency. It is no easy task to keep a large plant spick and span, year in and year out but logical rules, rigidly enforced, with suitable penalties for infraction thereof or appropriate regard for adherence thereto, will do much to keep any plant neat and orderly.

Chicago, Ill. WILLIAM SIBLEY.

Testing Boiler Tubes

IN A POWER PLANT where frequent tube-end failures had led to economizing by the repair of tubes by welding, the engineer found himself perplexed by an occasional failure of one of the welds, a leak developing after a tube had been expanded into place which necessitated another shutdown for the removal and replacement of the defective tube. The expense of such extra shutdowns led the engineer to rig up a tube-testing apparatus in his own plant.

A bolted flange union was procured, large enough so that when the union was taken apart and placed against the ends of the tube to be tested, the bolt hole in the union would lie outside of the tube so that rods could be put along the outside of the tube, thus connecting the union halves together, one at either end of the tube to be tested. The rod-ends were threaded and fitted with nuts for fastening the union-halves in place against the tube-ends.

Some heavy sheet packing was fitted to each union-half in such a manner as to close the tube-ends water tight. The packing was held permanently in place when the union-halves were not in use, by means of two or more short bolts in each union-half. A small hole was made in the center of each packing and by the aid of suitable reducers, a supply pipe was attached to one piece of union, and a discharge pipe and control valve was attached to the other half-union.

With this apparatus bolted in place upon a tube, the boiler feed pump would be connected by suitable pipe or hose and the far end elevated so the remaining portion of the tube could be filled with water without trapping any air inside of the tube. When the tube was full, the discharge valve was closed and the pump would run the pressure in the tube up, equal to that maintained in the boiler. When required to test to higher than boiler pressure, the boiler feed valve would be closed and full pump power would be available for testing purposes. Later, the engineer rigged an old safety valve into the test line from the feed pump and thenceforth was not obliged to watch the pump as closely while making a test.

Indianapolis, Ind. JAMES F. HOBART.

Why Take Readings and Then Not Refer to Them?

A PRACTICE much to be deplored among even good operators of fairly large plants is that of taking various readings when coming on watch and then not referring to them again during the entire watch. The reason for reading feed temperatures, steam pressure and possibly brine and service water temperatures is to maintain these constant at their most economical point and if recording instruments are not used, the chief must depend solely upon his operators.

Some product may be ruined if brine or water temperatures vary more than 10 deg. In a large packing house frequent complaints were made about the temperature of rooms that were served by a brine system. It was found that for maximum production brine temperatures must not exceed 10 deg. and any temperature below this while possible, meant lower suction pressure at the compressor and consequent increased load on an overloaded plant. The chief would not stand for brine under 7 deg. and the superintendent wanted less than ten. If an operator saw he had 7 deg. brine when coming on watch he was satisfied without troubling to learn if the temperature was on the way up or down. The only way to tell if the temperature is going down or up is to read the temperature again in a half hour. If the same reading is secured there is no cause for worry if the load is fairly constant; but if it happens to be 7 deg. and going down, prompt action is called for. Recording thermometers give this information, but it is not easy to have them provided. In one personal instance, reduced trouble with brine temperature led to the adoption of half-hour readings throughout the twenty-four hours.

Feed water temperature does not get as close attention in many plants as it should. The fact that the feed is 212 at one particular time causes many engineers to say that their feed temperature is constant at 212. When changing watches the load is frequently light, hence little water is pumped through the heater, causing maximum feed temperature. If it is not read again till the watch changes the temperature may drop 50 deg. without warning due to uneven feeding. In one boiler plant containing six 300-hp. boilers consuming 90 t. of coal per day 1½ t. were saved by watching the feed thermometer closely. The open heater would deliver 210 deg. feed water when the rate of flow was normal or just enough to replace the evaporation, but if a fireman decided he would run the water level up, the temperature would drop as low as 170 deg., depending on how fast the level was increased. The subsequent slowing down of the pump after this could not raise the feed to 210; it indicated that one of the traps was not work-

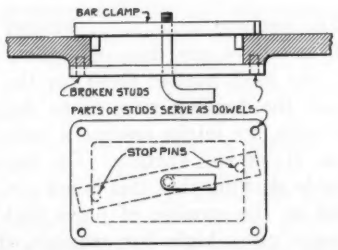
ing properly and a repairman was sent to correct the trouble.

If a fireman drops the steam pressure while cleaning fires or while the engineer is warming up another unit preparatory to changing engines, the economy of the plant is affected. If the load is heavy on engines and boilers, the case is more serious than may at first appear. With boilers already loaded beyond the economical point, the efficiency drops off with the increased steam flow that accompanies low steam pressure. The combination of increased load and reduction of pressure also increases the tendency to prime. Again, with Corliss or automatic cutoff engines the reduction of pressure may result in the engine being forced to take steam full stroke with sacrifice of efficiency. I know of one case where the engine was loaded to a point where the head and valve would admit steam full stroke with a 15-lb. drop in pressure three half-hour cleaning periods each day. The greater steam flow in turn reduced the vacuum from 26 to 24-in., causing the steam rate for a period of 1½ hr. a day to be approximately doubled.

Springfield, Mass. A. F. SHEEHAN.

Cover Clamp Replaces Broken Stud Bolts

WHEN THE studs for holding a hand hole cover in the base of a steam engine broke from repeated use and misuse, the repair means shown in the attached sketch proved to be the shortest and most economical. A



STEEL BAR WITH COVER PLATE FORMS SUBSTANTIAL SEAL

cross bar, provided at the ends with short stop pins, was made as shown in the sketch. A hand screw was made to shoulder against the cover and engage a tapped hole in the cross bar. Two of the broken off studs served as dowel pins to center the cover.

With the arrangement described, the entire cover may be removed without use of wrench or other tool. Another advantage of this arrangement lies in the greater tightness of the joint resulting in a better condition in the repair job than was experienced in the original installation.

Washington, D. C. G. A. LUERS.

Boosting Driven Wells

TROUBLE in obtaining sufficient water for a battery of boilers during peak load was experienced in a plant supplied from a group of driven wells. The wells were all pumped by a single large steam pump, the pipes from the several wells being connected to a larger pipe which acted as a receiver. The wells were disconnected, one at a time, the pipe to the water receiver plugged, and the well investigated by working or trying to work a hand pump which was attached to it. One of the wells responded with a good flow of water, one other gave very little water and the rest yielded none at all.

Each well was probed with a rod and some of the pipe was found to be completely closed by a deposit evidently formed from the water which has been drawn up for many months. Using a twisted auger without cutting lips which was forged and welded to a long rod, the deposit in the pipe was broken away. A piece of ¾-in. pipe attached to 1-in. hose was used as a nozzle. This was lowered into the well-pipe under water pressure and the deposit washed away. One of the wells recovered its water supply power when the deposit was removed from the pipe, but the other wells did not.

Three of them were found to yield very little or no water at all. These wells were dynamited. A stick of 40 per cent explosive was duly fitted with an electric exploding cap, lowered to the bottom of the well, being assisted when necessary by pushing with the long drill-rod. Care was taken to get the stick of dynamite to the very bottom of the well without damage to the wires or to their insulation. The dynamite was fired from a lighting circuit of 110 v. Two 45-w. incandescent lamps were connected in parallel across the firing circuit in such manner that whatever current went to the dynamite went through the two lamps.

After the dynamite had been exploded, the hand pump was connected to the well, and operated until water came up clear and free from sediment or dirt. The "boosted" wells proved as good as new for several months, then gradually their delivery fell off again and another investigation showed that the pipes from the dynamited wells had filled themselves completely with pebbles drawn and wedged with great tightness by the pump suction. As the dynamited wells failed, one after another, a new well was driven beside each old one and a new cycle of well-life was thus commenced.

Indianapolis, Ind. JACK BOSTON.

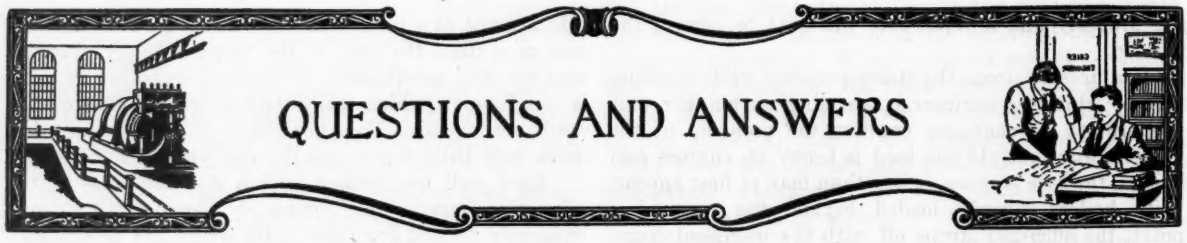
Comment on Home-Made Versus Manufactured Articles

MANY SMALL plants use home-made articles of more or less crude construction, nevertheless quite serviceable and efficient. These would probably not have been made if the approval of the cost had been decided by the purchasing agent.

Actual cost of making such home-made articles may not appear on the books. They may actually cost as much or more than purchased articles whose purchase may not be approved because of their cost. The trouble is that manufacturers reduce the strength of their apparatus, in order to meet competition, until the high-pressure steam now in common use distorts the apparatus to such an extent that it must be reconstructed on the job.

Before going to the expense of making an article in the home shop, operating engineers usually investigate the market in order to purchase suitable apparatus if they are permitted and if the price warrants so doing.

Lawrence, Mass. TOM THUMB.



Calculation for Heating System

MY COMPANY is building an addition at the extreme end of its present factory. It will be approximately 320 ft. from the boiler room. It will occupy a space 144 ft. by 52 ft. and have a length of 22 ft. The walls will be of brick, 12 in. thick; the foundation of concrete and floors of wood. It will be two stories high and of mill construction. What size steam line will this building require with a 5-lb. terminal pressure at the valve or boiler room There is a 4-in. line which is not quite loaded at the extreme end of the present building and the intention is to tie the two lines together. Some of the heat will be distributed through coils and some through the heating unit attached to the main steam line and a motor driven fan directly back of it to distribute the heat. This is a vacuum system, and the temperature will be about 60 deg. F. E. K.

A. In attempting a solution of the problem of finding the size of the steam line to heat your new factory building, the situation is complicated by the fact that you are going to use both unit heaters and direct steam radiation. We do not know the size of your unit heaters, nor what proportion of the total heating of the building they will provide.

Furthermore, we do not know how much of the wall space of the building will be windows. It is necessary to take into account, also, the effect of the prevailing winds and also the effect of moving machinery, electric lights, pulleys, belts, etc., and the number of people, all these factors having an appreciable effect. So many factors are involved in any such problem, however, and so many assumptions must be made, that any solution must be modified by the experience and judgment of the man on the job in each case.

We will, however, attempt to indicate roughly how you can get an approximate idea of the steam consumption for heating this building. We advise you, if you have many heating problems to solve, to get a copy of the latest American Society of Heating and Ventilating Engineers' Guide, which can be purchased for $3.00 from the secretary of the Society at 29 W. 39th St., New York City. You will find much helpful information in it. The coefficients and many of the data used below are taken from it.

We shall assume a tar and gravel roof construction. The maximum temperature difference you would have in winter would probably be about 60 deg. or from 0 deg. outside to 60 deg. inside. First, let us estimate the amount of heat loss under these conditions by infiltration and heat transmission, through walls, etc., assuming a 15 mi. per hr. wind.

The total surface is:

Roof 144 by 52 = 7488 sq. ft.

Lower floor 144 by 52 = 7488 sq. ft.

2 side walls 144 by 22 = 3168 sq. ft. × 2 = 6336 sq. ft.

2 end walls 52 by 22 = 1144 × 2 = 2288 sq. ft.

You do not state whether the walls will be covered inside or not but we will assume they will not. Each sq. ft. of 12 in. brick wall will transmit 0.27 B.t.u. per sq. ft. per hr. per deg. difference in temperature.

Let us assume the walls are ½ window. Each window will transmit 1.10 B.t.u. The coefficient for the roof is about 0.27 and for the floors about the same. Then for the roof:

7488 × 0.27 × 60 = 121,305 B.t.u. per hr. heat transmitted.

For the floor the same = 121,305 B.t.u.

For the walls—

Brick—3168 × 0.27 × 60 =	32,321.60
1144 × 0.27 × 60 =	19,524.80
Windows—3168 × 1.10 × 60 =	209,088.
1144 × 1.10 × 60 =	75,504.
B.t.u. heat loss per hr....	336,437.
Total—Walls	336,437
Floor	121,305
Roof	121,305
B.t.u. lost per hr.....	579,047

As we do not have any data on lights, moving machinery, etc., we shall neglect these for the present.

Now, if all the heating were to be done by single vertical wall coils, we might assume a radiation of 245 B.t.u. per sq. ft. of coil surface. On page 46 of the Guide is a table showing that this is not strictly correct, as it depends on the number of pipes high the coil is. For a coil eight pipes high, for example, the radiation would be 1200 B.t.u. per hr. per lineal ft. of coil of 1½-in. pipe. However, we will assume 200 B.t.u., but if we assume that about 1 lb. of the initial pressure will be used up in overcoming pressure drop and losses in the lines the amount of heat given up by the steam in condensing the water in the radiator coils will be approximately 190 B.t.u. per lb. Therefore, to supply 579,047 B.t.u. per hr. to make up for the heat loss under the maximum temperature conditions given we would need 579,047 ÷ 190 or approximately 3000 lb. of steam in all at an average pressure of about 4 lb. in the radiator coils.

From a Crane Company pipe table, for a flow of 3000 lb. of steam an hour or approximately 50 lb. a minute with an initial pressure of 5 lb. gage, a 6-in. pipe would give a flow of 40 lb. a minute with a pressure drop of 0.08 lb. per 100 ft. of pipe and an 8-in. pipe a flow of 70.72 lb. a minute with a drop of 0.05 lb. per 100 ft. of pipe at allowable pipe velocities.

At 10 lb. initial pressure on the main a 6-in. pipe would carry 49.25 lb. a minute with 0.1 lb. per 100 ft. drop and an 8-in. pipe 87.15 lb. a min. with a 0.69 lb.

drop. These pressure drops are figured for a velocity of 4000 ft. It would seem, therefore, that an 8-in. pipe certainly ought to be big enough under the above conditions.

In all the preceding computation, however, it has been assumed that all the heating will be done by vertical pipe coils placed on the walls. In your particular case, however, this will not be true because you are planning to put in some unit heaters. We do not know, of course, what the steam consumption of these unit heaters will be and it will be necessary for you to figure out just how much of your 3000 lb. of steam an hour would have to go to the direct radiation surface and how much to the unit heaters. Of course, the object of the unit heater is to produce a greater heating effect in a room with a given amount of steam by increasing the air circulation of the room or any part of it and, if the experience of many users of air heaters is to be depended on, the steam consumption will probably be less than with direct radiation. This is something on which we cannot help you very much unless we have full data about the air heater layout; however, we think that you can figure that out yourself on the basis of these comments. We think it would be well, however, in order to be absolutely safe, to figure the steam requirement as if it were to be of direct radiation. Then you will have a factor of safety.

The above calculation indicates the general method of procedure but we must insist that it is not to be taken as a definite answer, since we have had to assume so many variables. Such a computation is entirely different from the ordinary calculations of power plant equipment and heat transfer which the engineer has to make. It should not, under any circumstances, be made without careful consideration of the data given in the A. S. H. & V. E. Guide, from which the above coefficients were taken, because this Guide incorporates the results of long and expensive experiments by the most able private and government research workers. We strongly advise you to get a copy of this Guide. In about two hours of study you can understand the methods brought out for calculating various heating problems and will be able to tell whether or not we have made the proper assumptions in regard to your problems.

Double Eccentric Corliss Valve Setting

ON PAGE 584 of your May 15 issue you give directions for setting Corliss valves, but I feel that they are incomplete since you neglect to care for the double eccentric engine. Please supplement your directions.

C. W. G.

A. Centralizing the positions of the various parts is done by equalizing the movements and setting and adjusting the gear in practically the same manner as with the single eccentric engine. Set the wristplates central, and adjust the valve rods, giving the steam valves a negative lap of usually a little less than half the port opening.

We next set the exhaust eccentric, as it is placed next to the bearing. Turn the engine until the piston is in the desired position to obtain a compression of about 5 per cent of the stroke, then turn the exhaust eccentric loose on the shaft, in the direction the engine is to run, until the exhaust valves are line and line, then secure the eccentric.

Next we set the steam eccentric by placing the crank on either one of its dead centers, then turn the steam eccentric loose on the shaft until the steam valve at the end where the piston stands has the required opening or lead, which varies from $\frac{1}{32}$ in. to $\frac{1}{8}$ in. according to the size of the engine and speed it is to run.

Cause of Knocking in an Air Compressor

OUR SINGLE stage compressor with a clearance of $\frac{1}{32}$ in. between the piston and cylinder head knocks slightly at light load. Is it possible that this clearance between the piston and cylinder head is not sufficient and that this causes the knock? H. C.

A. You do not give the size of the machine, but in general, a compressor should have not less than an average clearance of $\frac{1}{16}$ in. plus the gaskets, which is equivalent to about a total of $\frac{3}{32}$, or say 100/1000, this being approximately 3 times the clearance you mentioned. However, even with this clearance it is advisable when adjusting a cold machine to give the cylinder more clearance on the head end than on the crank end, because after the machine is heated up, the elongation of the hot piston rod will be sufficient to make the piston hit the head end after being heated.

If the machine has plate valves which are easily removed, it is advisable after running the machine for some time to take out a valve at each end and actually test the clearance with a lead wire.

Feed Water Treatment

WE HAVE BEEN using soda ash and sal soda mixed with water for feed water treatment. As I understand it, when sal soda dries in a white powder condition, it is in the form of a sulphate; when it is in crystalline condition, its form is sulphite. How do these two forms differ in their action as feed water treatment materials?

J. F. W.

A. There is no essential difference in the action of soda ash and sal soda. Soda ash is a crude form of sal soda, which usually contains some other salts.

No change from sulphite to sulphate, such as you have supposed, takes place although the change from sulphate to sulphite is possible. Sodium sulphate is found in nature and is also obtained as a by-product in many industries. Sodium sulphite is a compound prepared by saturating a solution of sodium hydroxide or carbonate with sulphur dioxide and then adding the same amount of sodium hydroxide or carbonate as was originally introduced. It forms large crystals and is used medicinally.

Soda ash and sal soda are not sulphates or sulphites but sodium carbonate.

Combustion Control

WHICH OF the two following instruments is the more important in controlling combustion in a boiler: a draft gage, either single or differential, or a CO_2 instrument?

J. F. W.

A. It is more important to have a good draft gage than a CO_2 meter although there can be no real control of combustion conditions without the use of a CO_2 meter. A differential draft gage permits of more accurate readings and of greater ease of reading than a draft gage of ordinary type.

EDITORIAL COMMENT

Promoting Safety by Study Courses

Every industry presents physical hazards. In the power plant, not only does the mechanical equipment present dangers to the workmen but electrical circuits and devices present unseen dangers to those unfamiliar with the plant. Although general principles and rules will serve as a guide, each plant should be studied to correct arrangements that may sometime result in injury to somebody.

Each year the human race pays dearly in physical suffering for the privilege of walking erect on two feet, as is evidenced by the injuries reported due to falls. Floors, runways, stairs and ladders, when in the best of condition, call for some thought on the part of the user but, when neglected, they frequently become positive dangers. Obstacles overhead should not be tolerated but do sometimes exist temporarily, more is the danger, during construction or repair work. Around belts, gears and all kinds of moving machinery, safeguards should be provided to protect passersby and adequate guards should be placed around all exposed electrical circuits and equipment.

Just how far it will pay to go in providing safeguards is always a debatable question as accidents from identical causes may vary in degree from slight to fatal. No mechanical device, however, can take the place of intelligence on the part of workmen and for this reason plant managers are adopting the practice of putting workmen through courses in safety, devised especially for their local conditions and equipment. Each new workman should be taken on a trip through all parts of the plant where his work may call him and shown equipment and conditions where accidents might occur. Safe practices in the handling of coal conveying equipment, boilers, pumps, engines, turbines, generators, motors and electrical switching equipment can well be included in a course in safety for the power plant.

This is commendable work, for, with all men in a plant cooperating in promoting safety, a better environment is sure to exist than where some are thoughtless regarding the safety to others.

Over Fire Air Injection

Over fire air injection has been in use for many years, largely as a means or method of eliminating smoke. A few years ago a patent was issued covering this practice, or certain phases of it, while recently a number of engineering society papers and articles in the technical press have brought the subject into the limelight and started frequent discussions.

Some of the old timers drilled in keeping their boiler settings tight in order to force all the air up through the grates look askance at the scheme and many of them shake their heads and predict destruction of walls and arches. In a measure, they are correct. Sometimes the gain is doubtful and it requires some ingenuity to reduce erosion of the arches to a permissible amount. The fact remains, however, that a number of central stations are using it successfully for the elimination of smoke, greater turbulence in the furnace with a correspondingly better distribution of CO_2 and temperature and in some cases a considerable increase in efficiency.

Air injection by steam jets, air jets, separate fans or direct from the forced draft system is in use either permanently or experimentally in at least four large central stations in the middle west, while reports from a number of eastern stations are current. Results have been satisfactory and by proper arrangement of the injection pipes and draft pressures cutting of the arches can be stopped or at least kept down to where it is a negligible factor.

As yet, however, the practice is looked upon as a corrective one to remedy conditions due to poor furnace design, where it is necessary to burn a certain coal in a furnace designed for another kind of coal or when furnaces have to be fired at ratings beyond that for which they were designed. It should be considered as such and not as a panacea for all ills.

Proteus in Seven-League Boots

Considerable amusement was created among the readers of our January 1, 1927, issue by the title "Bigger and Better Turbines Ahead" which we gave to Professor Christie's able analysis of turbine development. It was suggested by several facetious engineers that this title should have read "Bigger, Better and Busier Turbines Ahead." Another engineer suggested that we might advocate a "Bigger and Better Turbine Week" along the same general line as "Better Onions Week," "Eat More Parsnips Week" and all the other weeks that various Mexican athletes seek to inflict upon our weary and tax-ridden citizenry.

All foolery aside, however, it is interesting to recall Professor Christie's comments in the light of the latest news in the large turbine field. In his article he referred to the 160,000-kw. unit under construction for Hell Gate Station. Now comes an announcement that another unit of 225,000 hp. capacity—about 170,000 kw.—has been ordered for the same plant. At Philo a 165,000-kw. unit is being installed; within the last month a 135,000-hp. unit has been ordered for Hudson Ave., and a 160,000-kw. unit for the East River and 14th St. station. Then, of course, there is the famous 200,000-kw. State Line unit.

"Installation of such large units" said Professor Christie, "has been warranted not so much on the basis of increased efficiency—as by decreased unit plant costs and by the suitability of such large units to carry the base load portions of the rapidly growing loads.

Such installations—and we may expect others in the

future—show also the care with which great public utility systems analyze their rapidly growing loads and take steps to handle them in the most economical way.

Public utilities have been able to plan on such large units, however, primarily because of the manufacturers. The latter have constantly increased their manufacturing facilities, have spent large sums on design, research and development work and as the demand for larger and larger units have increased, their ability to construct them and guarantee their performance has kept pace with that demand.

No industry has proved more ready than the power industry to adapt itself to rapidly changing conditions, to disregard precedents and prejudices and to look constantly ahead. It seems to us that a fitting statue to symbolize the industry might be executed by some great sculptor showing Proteus, the god of Greek mythology, who was able to change his size and appearance instantly, striding along the path of human progress and wearing on his feet the famous Seven-League Boots.

Off Duty

Have you, in this terribly modern world, ever paused long enough to reflect seriously over some of the things you do and just why you do them? Why, for instance, if you have an automobile, do you draw up besides a filling station pump which is painted red rather than one which is painted yellow? Why do you buy the tooth paste you are using—What do you know about its relative merit compared to other tooth pastes—do you know whether it has, beyond a pleasant taste, any merit at all? How do you know whether the electric refrigerator you just bought is technically the best within the range you can afford to pay? Do you know whether the shirt stamped "English Broadcloth" is really made of the broadcloth you paid for or some clever imitation? Take that cake of soap you buy—is it actually 99$^{44}/_{100}$ per cent pure and will it give you that school-girl complexion? Why did you buy that "solid mahogany" table—do you know whether it is solid mahogany—what guarantee have you beyond the mere label? Have you ever thought seriously about these things?

If you have or if you haven't, you will probably be interested in a recent book by Stewart Chase and F. J. Schlink for this book discusses these matters from the standpoint of the ultimate consumer. With everything from hairpins (now useless) to 8-cylinder limousines and co-operative apartments advertised as best and with dozens and scores of makes to select from, how is the consumer ever to determine what is best? On all sides the consumer is urged to buy, buy while no means are offered him whereby he may use intelligent selection in his buying. All the tricks of psychology, every appeal to sentiment and romance, is hurled at him from every direction. Dare he ignore the commands of high pressure salesmanship?

"Here," quoting from the book, "is a soap which will bring a new kind of cleanness. We have a picture of the young man who uses it dancing with a charming girl—'Of course she likes him better. The other fellow dances well—a fine chap, but—you know—a bit careless. To be frank, not pleasant to dance with'."

"What is this subduer of charming ladies; this new kind of cleanness? A little cresol, a common cheap disinfectant, recommended by the government for disinfecting cars, barns and chicken yards."

Again we have an antiseptic solution used widely as a mouthwash. It is said to sweeten the breath and terrify germs. Perhaps it does, say Messrs. Schlink and Chase, but what is it? Plain thymol plus small quantities of boric and benzoic acid. It would take $495 worth of it, to effect the same antiseptic action as one cent's worth of corrosive sublimate—this from a report of the American Medical Association.

In presenting the mass of evidence contained in the book, the authors have an object in mind. In exploring the Wonderland in which the consumer of today finds himself, their purpose is to indicate a path that may lead out of it. Their plea is for an extension of the principle of buying goods according to impartial scientific test, rather than the fanfare and trumpets of the higher salesmanship.

The United States Government, they point out, has solved this problem some time since for its own purpose and provides a working model of how to do it, and what is to be gained by it. Each year the Government buys some $300,000,000 of supplies and equipment—ranging all the way from thumb tacks to dredging machines—from base balls to battleships. Nearly everything the general consumer buys, the Government buys. But in buying much of this material the purchasing agents pay little attention to the pretty girls in the selling literature or to the super-salesmen with pants like the Prince of Wales. They pay attention to technical advice from the Bureau of Standards. For an operating cost of $2,000,000 a year it is estimated that the Bureau of Standards saves the Government in the neighborhood of $100,000,000 every year.

Take the case of a preparation used for moistening mimeograph stencils. This costs the consumer $3.20 per gal. in eight-ounce bottles. Made by the Government for its own use according to a formula worked out in its laboratories, a compound costing 5 cents a gallon is equally good. For years the Government had been buying varnish at $4.37 or thereabouts a gallon. The Bureau of Standards, with other industrial experts, worked out specifications for an outside spar varnish which in 1926 cost 78 cents a gallon. The United States Navy can lay down a specification for an officer's overcoat which will stand steady wear for ten winters. Will the overcoats you buy do that? If they will, can you prove it in advance?

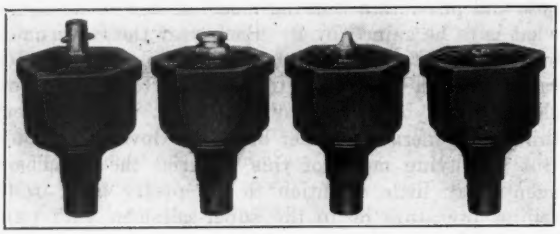
Mother's day and father's day and eat bananas week mean nothing to the government purchasing agents. They buy when they need, know what they want when they need, and they get it. If the same principles of buying could be used by the average consumer, untold millions of dollars could be saved annually.

To conclude, "Your Money's Worth" is an exceedingly interesting book and the authors have filled it with an immense amount of concrete information. Both men are qualified to discuss the subject. Mr. Schlink is a mechanical engineer-physicist and assistant secretary of the American Engineering Standards Committee; for years he was a member of the staff of the Bureau of Standards. Stewart Chase was for some years on the staff of the Federal Trade Commission and is now a director of the Labor Bureau, Inc.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Hex-Top Malleable Iron Grease Cup

OF INTEREST to all manufacturers whose processes or fabrication require the use of grease cups should be the announcement of Link-Belt Co., Chicago, Ill., of its new "Hex-Top" malleable iron compression grease cup with Alemite or Zerk fittings, as shown in the



HEX-TOP GREASE CUP IS FURNISHED WITH VARIOUS TYPES OF ALEMITE FITTINGS

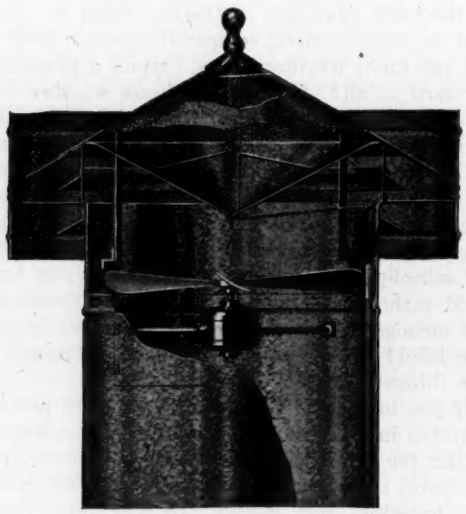
illustration. The grease cup head is six-sided, to offer an easy purchase for any type of wrench and a good grip for the hand.

The cup is designed for filling without waste of grease and without any inconvenience; the cup holds a good reserve for use of the compression feature and an occasional slight screwing down by hand or wrench is all that is necessary until it is time to have a general refilling of the cups. If a bearing gets warm when the grease gun is not at hand, a turn or so of the cap takes care of the emergency. The cup may be readily filled in even the most inaccessible places.

Burt Direct-Connected Fan Ventilator

FOR USE in locations where stationary and revolving ventilators are not of sufficient capacity to exhaust the proper amount of vitiated air, a power-driven fan ventilator has been developed by the Burt Manufacturing Co., Akron, Ohio, designed to exhaust approximately ten times as much air. As shown in the illustration, the construction of this ventilator is similar to that of the stationary ventilators manufactured by this company with the addition of a motor-driven exhaust fan located as shown. With this ventilator, the power is turned on only when conditions are most severe and when they return to normal or when work has ceased the power is shut off and the ventilator functions just as an ordinary ventilator would in handling the less severe conditions.

These fan ventilators are made in three distinct types, their grouping depending only upon the way in which they are driven. Group 1 consists of a direct connected fan ventilator in sizes from 14 in. to 20 in. In these sizes the fan and its casting are supported on the shaft of a vertical motor which is held in the ventilator shafting on a 3-way support. This small direct-connected unit can be operated on 110 or 220 v. a.c. or d.c. The 14-in. and 16-in. sizes are designed to deliver 1440 to 1550 cu. ft. of air a minute and to consume about 54 watts. The 18 and 20 in. sizes are designed to deliver about 1600 to 1750 cu. ft. of air a minute and to consume about 93 watts. For mounting on the roof, bases complete with roof flashing are furnished to insure rigid installation, but if the fans are to be mounted on stacks these bases can be omitted.



FAN AND MOTOR ARE SUPPORTED IN VENTILATOR SHAFT IN THIS TYPE

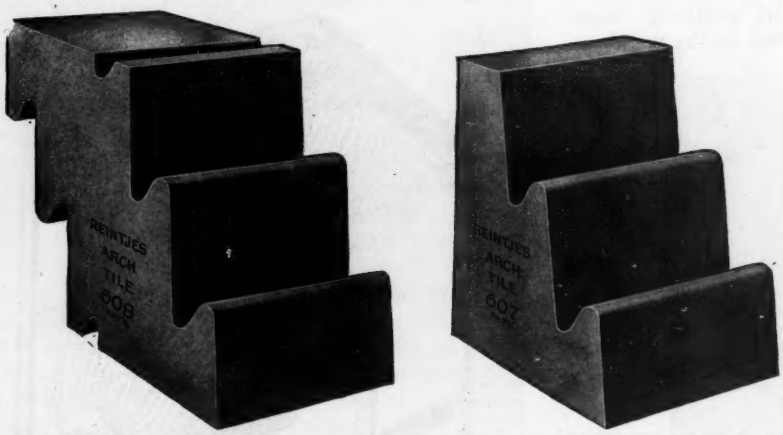
Group 2 consists of the larger direct-driven fan ventilators suitable for use in larger industrial plants, schools, auditoriums, churches and so on. In this group also, the motors are direct-connected to the fans, and are held on a three-way support fastened to the ventilator housing by a vibration absorber designed to deaden the vibration and sound. In these large ventilators the motors are equipped with ball bearings at both ends of the rotating shafts. They are fully enclosed to protect them when handling steam, smoke, fumes and so on, and are arranged for proper lubrication. Motors for these can be supplied for operation on 110 to 220 v. single phase, or 220 to 440 v. three phase, a.c. in either 60 or 25 cycles. Series one d.c. motor for 110 to 220 v. can

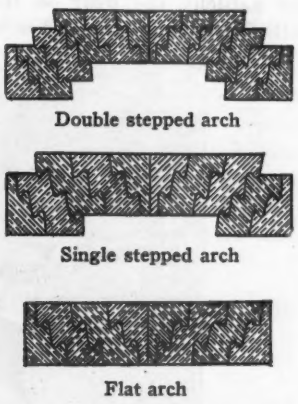
also be supplied. Under test these ventilators have shown a capacity from 4500 cu. ft. a minute for the 24-in. size up to 14,725 cu. ft. a minute for the 48-in. size.

Group 3 consists of belt-driven fan ventilators of four types. These can be driven from line shafting or from individual motors. When used with line shafting they can be equipped with either outside drive or inside drive, depending on whether the line shafting is to drive a long row of ventilators in series or whether other machinery is driven from the same line shaft. In a third type, a separate motor on the outside of the building can be used to drive the fan by belt. In a fourth type, a separate motor driving the fan by belt can be placed inside the building below the ventilator shaft with suitable idlers directly under the fan. Motors can be supplied with electrical characteristics to suit the particular conditions. The fans in these ventilators are made to be driven between 500 and 650 r.p.m.

Flexible Arch Tile Forms Its Own Arch

DESIGNED FOR economical and easy arch construction and maintenance, a new flexible arch tile has recently been developed, known as the patented Reintjes flexible arch tile. This is designed to form its own arch and to require no temporary arch centers or skewbacks and no iron or steel. Only two shapes of tile are needed, as shown in the illustration, regardless of thickness of walls or the varying width of span, or whether the door jambs are square or bevelled.





ONLY TWO TILE SHAPES ARE REQUIRED AS SHOWN IN LEFT AND CENTER VIEWS. AT RIGHT ARE SHOWN METHODS OF INSTALLATION

The tile is designed so that no levelling is required, as is necessary with sprung arches. Units remain level with adjacent brickwork without any levelling medium. Each step up is equal to a brick course and the arch is built up in sections the width of one brick course.

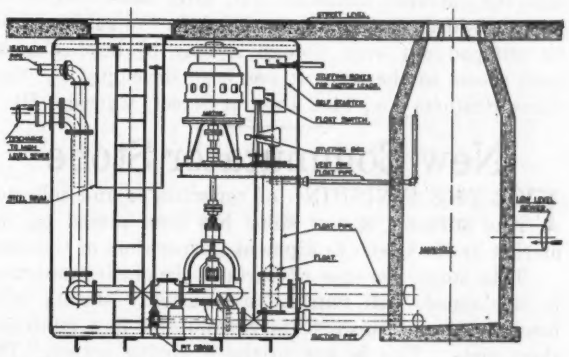
The tapered key of the Reintjes Flexible Arch Tile is intended to facilitate repairs. Replacement arches can be driven to a tight fit without disturbing overhead brickwork. The interior section of the arch can be repaired without interfering with the remaining sections.

Reintjes Arch Tile is designed to improve arch construction in firing doors, observation doors, relieving arches of side walls, rear arches h. r. t. boilers, roof arches for any type of furnace, bridge walls with or without waterbacks and many others.

This patented arch tile is being marketed by the Geo. P. Reintjes Co., Kansas City, Missouri.

Sewage Pumping Station Made Flood-Proof

IT IS generally admitted by competent engineers that electric motors and controlling devices used to operate sewage pumps should never, unless absolutely necessary, be located in underground chambers or vaults where they may be injured by excessive dampness and lack of attention. In some localities, however, because of the inability of the municipality to secure the necessary prop-



ELECTRICAL EQUIPMENT IS LOCATED IN AN AIR POCKET WITHIN A STEEL DRUM

erty adjacent to sewer lines for the construction of housing for electrical equipment above the surface, the installation of motors and controllers underground cannot be avoided.

In such cases there is possibility of damage from condensation and lack of ventilation in the vault, also of complete submergence of the equipment under flood conditions and the new Yeomans Flood Proof Underground pumping station (patented) has been designed to prevent the complete filling up of such an underground chamber under any conditions that are likely to occur.

As shown in the illustration, the unique feature of this station is the steel drum which forms the entrance to the chamber and extends down to a point considerably below the level of the electrical equipment. Motors and controllers are located in an air-locked space in the upper part of the chamber and, even with a considerable head of water over the top of the chamber and with the cover removed from the entrance manhole, the water in the chamber cannot rise far enough above the bottom of the entrance drum to reach the motor windings.

Power wires for the motor are brought in through the steel wall of the chamber with stuffing-boxes and the ventilating pipes, if any, are carried down to the same level as the entrance drum so that air cannot possibly escape at any point above this level. The pit drain valve, which is connected to the suction of the sewage pump, is provided with an extension stem running up into the entrance drum so that, after flood conditions have subsided, the water remaining in the chamber can be pumped out even though it may be impossible to gain access to the pit. It has been developed by Yeomans Brothers Co., 1432 Dayton Street, Chicago, Ill.

New Commutator Stone

FOR THE FINISHING of commutator and collector ring surfaces, a new stone has been placed on the market by the Green Equipment Corporation of Chicago.

This stone, because of certain chemical properties, it is claimed, will impart an unusually smooth blue black, hardened finish to the commutator in a relatively short time. This is due to the oxidizing action. The stone does not burnish. It cuts metal while it smooths and as the surface of the commutator or ring oxidizes and hardens, the wear on the stone gradually ceases until further application has no effect on the metal.

ACME OXIDIZING STONE IN USE

Although known as the Acme Oxidizing stone, the makers state that it is actually not a stone but a block of chemical compound intended to be used on commutators and collector rings whose surfaces have until the time of application been accepted as ready for the brushes.

Two other new stones are announced by this company, the improved Acme "cutting" and "smoothing" stones which may be used on either commutator or collector rings. These three new stones form a complete set of grades for the maintenance of direct-current machines. They are claimed to be fast cutting stones which will not drag metal between the bars.

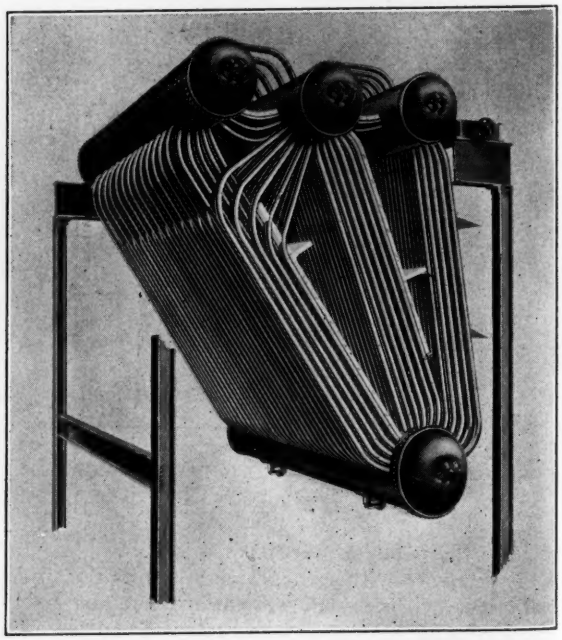
Diesel-Electric Tanker Goes Into Operation

FIRST OF THE THREE new Diesel-electric tankers for the Atlantic Refining Co., the Point Breeze, was placed in operation on July 25. This boat, which was originally called the J. M. Connally, was reconditioned by the Atlantic Refining Co. at its Point Breeze plant and, together with the other two, was purchased from the U. S. Shipping Board. The remaining boats, the Sharon and the Bessemer, are being reconditioned by the Alabama Drydock & Shipbuilding Co. at Mobile, Ala., and are expected to go in service on Sept. 15.

Each of the boats has a dead weight of 7000 t. They were formerly operated by steam, but the new power plants each consist of Ingersoll-Rand Diesel engines and electric equipment furnished by the General Electric Co. Each tanker is equipped with three 850-hp., 225-r.p.m., Diesel engines, each driving a 525-kw., 250-v. generator for propulsion and a 50-kw., 250-v. auxiliary generator for excitation and ship's auxiliary power. The propulsion generators will supply power to an 1800-hp., 90-r.p.m., 750-v., double motor on each boat, direct connected to the propeller shaft.

New Boiler Has Large Steam Liberating Surface

DIFFERING from the conventional four-drum bent-tube boiler in that the upper end of alternate rows of tubes in the first bank are connected to the middle drum instead of all being connected to the front drum, the new four-drum boiler manufactured by Walsh & Weidner, Chattanooga, Tenn., has been announced.



ALTERNATE ROWS OF TUBES IN THE FIRST BANK GO TO THE MIDDLE DRUM SO AS TO PROVIDE A LARGE STEAM LIBERATING SURFACE

Tubes are arranged so that any tube may be removed

without disturbing any other tube or the boiler brick work. While the three-pass boiler is standard, four or five passes may be employed and the boilers are built in single units up to 2500 hp. and 400 lb. per sq. in. pressure.

Over 70 per cent of the steam is produced in the front bank and in the conventional type boiler this is all liberated in the front drum, while in this new boiler it is distributed between the front and middle drums. As a result, it is claimed that there is no wide fluctuation of water level under rapidly changing load conditions, and the front drum does not become flooded while dry steam is provided at all ratings with no possibility of the rear drum running dry while there is water in the front and middle drums.

Feed Water Studies Committee Reports Progress

PROGRESS of the Boiler Feed Water Studies Committee sponsored by the A. R. E. A., the A. W. W. A., N. E. L. A., A. S. M. E., A. S. T. M. and A. B. M. A. was reported at the recent annual meeting of the American Water Works Assn. at Chicago by Chairman Sheppard T. Powell.

Technical committees are now functioning and a comprehensive program is prepared for the following year. Extensive bibliographies with short extracts of all interesting articles on feed water treatment or allied problems that have appeared in the technical press of this country or abroad have been prepared. Funds required for this undertaking will amount to from $40,000 to $60,000 per year for a period of 3 to 5 yr., as it was realized at the beginning of the enterprise that paid research was essential.

Some of the important problems which are to receive attention this year are the prevention of after reaction in chemical softeners, the economies that may be effected by the use of zeolite softening or chemical softening in conjunction with evaporators, embrittlement of boiler steel, the use of inhibiting agents other than sulphates, the effect of trade waste on surface condenser operation and in boiler feed water treatment, the value and economy of continuous blowdown apparatus, the importance and value of electric methods of preventing scale and corrosion, studies on the corrosion of boiler metal, condenser tubes and other equipment and causes and method of control of foaming and priming.

Program Announced for First National Fuels Meeting

FOR ALL engineers interested in use and conservation of fuels, an interesting meeting, entitled "The First National Fuels Meeting" has been arranged by the Fuels Division of the American Society of Mechanical Engineers, to be held in St. Louis, Mo., from October 10 to 13, 1927.

Men prominent in the engineering and research field have been secured to deliver papers and address and the entire program will be devoted to the most effective utilization of our great natural fuel resources. The advance program as announced by the publicity committee is as follows:

General

"Address on Fuels"—Prof. S. W. Parr, Professor of Applied Chemistry, University of Illinois, Urbana, Ill.
"American Fuel Resources"—O. P. Hood, Chief Mechanical Engineer U. S. Bureau of Mines, Washington, D. C.
"Combustion and Heat Transfer"—Prof. R. T. Haslam and H. C. Hottel, Massachusetts Institute of Technology, Cambridge, Mass.
"The Clinkering of Coal Ash"—A. C. Fieldner, Chief Engineer of Experiment Stations, U. S. Bureau of Mines, Pittsburgh, Pa.
"Factors Governing the Purchase of Fuels"—Morgan B. Smith, Engineer, General Motors Corp., Detroit, Mich.
"Refractories for High Temperature"—Stewart Phelps, Director of Research and Tests, American Refractories Institute Fellowship, Mellon Institute, Pittsburgh, Pa.
"Coal Mining and Coal Preparation From Standpoint of Quality."
"Recent Developments in Low Temperature Coal Carbonization"—H. D. Savage, Vice-President, Combustion Engineering Corp., New York, N. Y.

Industrial

"Industrial Applications of Heat"—Prof. W. Trinks, Professor of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa.
"Progress in Gas Producer Practice"—W. B. Chapman, President, Chapman Engineering Co., New York, N. Y.
"Application of Powdered Fuel to Smaller Boiler and Industrial Installations"—H. W. Brooks, Consulting Engineer, Erie City Iron Works, Erie, Pa.
"Rotary and Vertical Kilns for Cement, Lime and Gypsum."
"The Use of Fuels in Brick Kilns"—W. E. Rice, Assistant Fuel Engineer, U. S. Bureau of Mines, Pittsburgh, Pa.
"The Burning of Liquid Fuels"—Ernest H. Peabody, President, Peabody Engineering Corp., New York, N. Y.
"The Relative Values of Gaseous, Liquid and Solid Fuels"—F. C. Binnall, Assistant Manager, Standard Sanitary Mfg. Co., New Brighton, Pa., formerly Chemical Engineer, General Oil & Gas Corp.

Power Plant

"Characteristics of Modern Boilers"—E. R. Fish, Vice-President, Heine Boiler Co., St. Louis, Mo.
"Characteristics of Modern Stokers"—F. H. Daniels, President, Riley Stoker Co., Worcester, Mass.
"Air Preheaters"—Frank M. Van Deventer, Special Engineer, Henry L. Doherty Co., New York, N. Y.
"Direct Fired Powdered Fuel Boilers With Well Type Furnaces at Charles R. Huntly Station"—H. M. Cushing, Chief Engineer, Buffalo General Electric Co., Buffalo, N. Y.
"Automatic Combustion Control"—J. A. Peebles, Chief Engineer, Hagan Corp., Pittsburgh, Pa.

Smoke Abatement

"The Measurement of Atmospheric Smoke Pollution, Visible and Invisible"—Dr. Geo. T. Moore, Director, Missouri Botanical Garden, St. Louis, Mo.
"Smoke Abatement Methods Used in Cleveland"—Col. Elliott H. Whitlock, Commissioner of Smoke Inspection, Cleveland, O.
"Managing a Smoke Abatement Campaign"—Erle Ormsby, President, Citizens' Smoke Abatement League, St. Louis, Mo.
"Furnace Essentials for Smokelessless"—H. B. Meller, Chief, Bureau of Smoke Regulation, Pittsburgh, Pa.
"Smokeless and Efficient Firing of Domestic Furnaces"—Victor J. Azbe, Consulting Engineer, St. Louis, Mo.
"The Effect of Atmospheric Smoke Pollution—a Summary of Opinions From Current Literature"—Prof. A. S. Langsdorf, Director of Industrial and Engineering Research, Washington University, St. Louis, Mo.

Power Specialty Co. and Wheeler Con. & Eng Co. Consolidate

CONSOLIDATION OF the Power Specialty Co. and the Wheeler Condenser & Engineering Co. has recently been announced. Assets, plants, engineering, research, sales departments and subsidiaries of both companies will now be assembled under one corporate identity to be known as the Foster Wheeler Corp.

No changes in products are contemplated, as there has been no competition or overlapping of effort in the past. The products of each company complemented those of the other, but there is the great advantage that both were sold to the same industries and often to the same customers. The products of these companies are superheaters, economizers, water-cooled furnaces, air heaters, tube stills, unit coal pulverizers, condensers, pumps, cooling towers, feed-water heaters, evaporators, fractionating equipment and heat exchangers. These are built at Dansville and Newburgh, N. Y., at Cartaret, N. J., St. Catharines, Ontario, Canada, and at Egham,

Surrey, England. The companies have branch offices throughout this country and subsidiaries in Canada and Europe. Thus, the combination of departments is intended to effect valuable economies and the increased plant facilities with greater volume and buying power should result in desirable savings.

No change in management will be made and former conservatism coupled with advanced research and engineering will be maintained. The new officers will be those of the old companies, as follows: J. J. Brown, chairman of the board of directors; Pell W. Foster, vice-chairman and treasurer; L. B. Nutting, president; John Primrose, vice-president; H. S. Brown, vice-president; W. E. Dowd, Jr., vice-president; David McCulloch, secretary and general manager; W. F. Keenan, Jr., chief engineer.

The new corporation will have no securities prior to 35,000 shares of preferred stock and 194,000 shares of no par value common stock. The combined assets are approximately $12,000,000.00.

Empire District and Kansas G. & E. Co. Plan Interconnection

THROUGH PROPOSED interconnection of transmission lines an exchange of power between the operating systems of the Empire District Electric Co. and the Kansas Gas & Electric Co. will soon be made possible by construction work now under way. This announcement was made by C. Pratt, General Supt. of the Empire District Electric Co. of Joplin, Mo.

By this interconnection the Empire District will rereceive needed increased capacity temporarily from its plant at Riverton, Kansas, and the facilities of each company will be made available for the other in case of emergency. When this connection has been made there will be a complete system of electrical connection from a point north of Wichita, Kan., to the Ozark Dam south of Springfield, Mo. The Kansas Gas & Elecric Co. has recently added 25,000 kw. capacity to its Neosho River plant which gives the company considerable capacity in excess of present requirements and the interconnection will make possible the utilization of part of this generation by the Empire system. It is planned that when the combined requirements of the companies exceed present combined generating capacity the Empire District will install additional generating equipment and in the future these additions will be made alternately by the two companies.

A complication arises in this interconnection due to the fact that the Kansas Gas & Electric Co. system is operated at a frequency of 60 cycles, while the Empire system frequency is 25 cycles, thus requiring a frequency changer at the Riverton plant. This frequency changer will have a capacity of 25,000 kw.

News Notes

AMERICAN INSTITUTE OF STEEL CONSTRUCTION will hold its Fifth Annual Convention October 25—29, at Pinehurst, N. C. Complete information can be obtained from the executive director, Charles F. Abbott, 285 Madison Ave., New York City.

WHEN THE ELEVENTH EXPOSITION OF CHEMICAL INDUSTRIES opens at Grand Central Palace at New York City on September 26, a large and varied collection of exhibits will be available. For the first time in the history of the Exposition, foreign methods and practices will be shown for comparison with those used in this country. Complete information may be obtained at the office of the manager in the Grand Central Palace Building.

H. T. SANDS, President of the National Electric Light Association, has announced the appointment of the association's four National Section chairmen for the year 1927-28.

These are, for the Commercial National Section, J. E. Davidson, Omaha, Neb., vice-president and general manager of the Nebraska Power Co., reappointed; for the Accounting National Section, E. A. Davis, Chicago, auditor, Middle West Utilities Co.; for the Engineering National Section, E. C. Stone, Pittsburgh, Systems Development Manager, Duquesne Light Co.; for the Public Relations National Section, J. F. Owens, Oklahoma City, vice-president and general manager, Oklahoma Gas and Electric Co.

FALL MEETING of the American Welding Society will be held at the Book Cadillac Hotel, Detroit, Mich., September 19 to 23. Papers to be presented which will be of special interest to power plant executives are: A Study of Welds by G. R. Brophy, research laboratory of General Electric Co., Tuesday, September 20, at 2 p. m.; Production Welding of Water Heaters by H. J. Grow, Air Reduction Sales Co.; Welding in the Plant of Combustion Engineering Corp. by C. S. Reed, vice president and general manager. Social events and inspection trips for ladies and men will be arranged, also a welding and cutting exposition will be in progress in co-operation with the National Steel and Machine Tool Exposition, occupying 10,000 sq. ft. of space.

IN THE LIST of those societies mentioned on page 859 of the August 1 issue as sponsoring the First Steel and Power Show to be held on Aug. 31 to Sept. 2, the general chairman, C. Bradshaw of Toronto, states that the following should also be included: Ontario Section of the American Society of Engineers, the Industrial Accident Prevention Associations of Ontario and the Canadian Engineering Standard Association.

KIELEY & MUELLER, INC., New York City is now represented on the Pacific Coast by The Fulton Engineering Co. of Los Angeles, Calif.

DAYTON-DOWD CO., Quincy, Ill., announces the appointment of E. G. Dewald, 2—6 S. West Temple St., Salt Lake City, Utah, as its representative in that district.

PENNSYLVANIA PUMP & COMPRESSOR CO., Easton, Pa., announces the appointment of P. I. Perkins Co., 110 High St., Boston, Mass., as its representative in the Boston territory.

PIONEER RUBBER MILLS, San Francisco, Calif., has appointed the McKinnon Iron Works as distributors for Skookum piston rod packing for Ashtabula, Ohio, and nearby territory.

UNION ELECTRIC MFG. CO., Milwaukee, Wis., announces the opening of a district office for the States of Louisiana and Mississippi, at 501 Tchoupitoulas St., New Orleans, La., to be in charge of G. P. Robbins and G. P. Robbins, Jr.

LINCOLN ELECTRIC Co. has moved its Missouri office from St. Louis to 1003 Davidson Bldg., Kansas City, in charge of Robert Notvest. It has also established a branch office at 220 Nicholas Bldg., Toledo, Ohio, with A. H. Homrighaus in charge.

THE NARRAGANSETT ELECTRIC LIGHTING Co. of Providence and other Rhode Island communities has been valued at $46,240,000 by consulting engineers, according to reports filed with the Rhode Island Public Utilities Commission in connection with the petition of the United Electric Power Co.'s petition to be permitted to issue securities to finance the purchase of the Narragansett company.

During the hearing it was brought out that the Narragansett company owned a site in Bristol, R. I., which was acquired some years ago, as a possible location of a power plant on tide water, when the growth of the company's business should warrant the erection of such a plant.

Luke C. Bradley is president of the United Electric Power Co., the Narragansett Electric Lighting Co. and the Rhode Island Public Service Co., which are proposed to be merged.

HENRY O. SEYMOUR, since 1918 a director of Chain Belt Co., Milwaukee, Wis., died of heart failure on July 23, at his country home at Lake Geneva, Wis.

FREDERICK M. FISK has been appointed manager of the Pacific Coast office of McIntosh & Seymour Corp., 815 Sheldon Bldg., San Francisco.

WARREN WEBSTER & Co., Camden, N. J., has acquired the inventions of James A. Donnelly and the physical assets of the Donnelly Systems Co. of New York. The business of the latter company has been liquidated.

THE LEXINGTON WATER POWER Co., Lexington, S. C., has awarded a general contract to the Arundel Corp., Baltimore, Md., for the construction of its proposed hydroelectric generating plant on the Saluda River about 10 mi. from Columbia.

CHICAGO CHEMICAL Co., Chicago, Ill., announces the appointment of Dr. G. J. Fink as head of its new research department. Dr. Fink was formerly chemical director of the National Lime Association with headquarters in Washington, D. C.

CRANDALL PACKING Co., Palmyra, N. Y., announced that O. W. Wagner has been appointed director of sales, after 21 yr. of service with the company. He will be located at the New York office of the company at 109 Liberty St.

THE SUPER POWER Co. of Illinois, Samuel Insull, president, 72 W. Adams St., Chicago, is making plans for a new steam power plant at Pekin, Ill., with a capacity of about 250,000-kw. Sargent & Lundy, 79 W. Monroe St., are engineers.

THE ATMOSPHERIC NITROGEN Co., Hopewell, Va., operated by the Allied Chemical & Dye Corp., 61 Broadway, New York, has engaged Stone & Webster, Inc., 49 Federal St., Boston, Mass., to prepare plant for a proposed steam-operated electric power plant for service at its new nitrogen works.

ON JULY 1, the filling of Horse Mesa Lake on the Salt River Valley project at Phoenix, Ariz., was completed and the first water was allowed to flow over the spillway of the dam. This dam is 250 ft. high and a 10,000-kw. hydro-electric plant will be operated in conjunction with it.

PRODUCTION OF BITUMINOUS COAL for the week ending July 2, including lignite and coal coked at the mines, is estimated at 7,974,000 net tons, by the Bureau of Mines, Department of Commerce. Compared with the output of the preceding week, this shows a decrease of 505,000 t., or 6.0 per cent. This loss, it is stated, was confined to Friday and Saturday, and was apparently due to the approach of Independence Day, July 4. The total quantity of soft coal produced during the year ending July 2 is 278,601,000 net tons.

Total production of anthracite during the week ending July 2 is estimated at 1,279,000 net tons, a decrease of 306,000 t., or 19.3 per cent from the output in the week of June 25. This decrease also was apparently associated with the approach of Independence Day.

PRODUCTION OF ELECTRIC POWER by Public Utility Power Plants in the United States for May, as reported by the Geological Survey, Department of the Interior, was 6,515,570,000 kw.-hr., an increase of 11 per cent over that of May, 1926.

LIEUT.-COL. G. F. JENKS, Rock Island Arsenal, was elected chairman of the tri-city section (Davenport, Ia., Moline and Rock Island, Ill.) of the American Society of Mechanical Engineers, at the annual election recently. Other officers are: E. D. Quirke, Kewanee Boiler Works, vice president; Charles A. Carlson, John Deere Plow Works, secretary-treasurer; Thomas L. Wilkinson, Davenport; A. E. Lindberg, Moline Tool Co., and Louis Ruthenburg, Yellow Sleeve Valve Engine Works, executive committee.

THE NEW ENGLAND POWER Co. has acquired, by purchase, the Webster & Southbridge (Mass.) Gas & Electric Co. The price paid was $410 per share for the 8000 shares held by some 300 stockholders, par value of which was $100, making the purchase price $3,280,000.

ROCHESTER GAS & ELECTRIC Co., Rochester, N. Y., will soon begin work on a proposed hydroelectric power project in the Genessee Gorge, near Mount Morris, N. Y., to cost about $10,000,000.

THE LOUISIANA POWER & LIGHT Co., Pine Bluff, Ark., has ordered structural steel for the proposed addition to its local steam-operated electric generating station at Sterling, La. Ford, Bacon & Davis, Inc., is appointed as engineer.

BURTON L. DELACK, assistant manager of the Schenectady works of the General Electric Co. since December 1, 1926, has been appointed acting manager, effective July 1, according to an announcement by Vice President C. C. Chesney. Mr. Delack fills the vacancy caused by the promotion of C. E. Eveleth, elected a vice president on June 1 of this year.

Edward A. Wagner, formerly of the Fort Wayne works but since July, 1926, managing engineer in charge of all distribution transformers, with headquarters in Pittsfield, has been made acting manager of the Pittsfield works, succeeding Mr. Chesney, who has been a vice president in charge of manufacturing since the retirement of F. C. Pratt.

Giuseppe Faccioli, works engineer of the Pittsfield works, has been appointed associated manager and works engineer of the Pittsfield works, Mr. Chesney announced.

THE ELECTRIC SERVICE CO., Odessa, Texas, affiliated with the Texas Light & Power Co., Dallas, Texas, has begun Construction of a new steam power plant to have an initial capacity of about 10,000 hp., to serve the oil fields in that vicinity. M. J. McCall is division engineer in charge.

Books and Catalogs

"ELECTRIC SWITCH AND CONTROLLING GEAR," by Chas. C. Garrard, third edition, 782 pages; size 6 by 9, cloth, $18.00, New York, 1927.

It would seem after carefully examining this 782-page volume that if there are any facts concerning electric switch gear that are not contained in it they must, indeed, be unimportant. In its third edition this is the most complete treatise we have ever seen on the general subject of switch gear engineering. Written by an Englishman, it is done in the accustomed thorough English manner.

To describe the book in detail would require a volume in itself but to give the readers of this notice an idea of what it contains we will list briefly the chapter headings and some of the subjects treated in these chapters:

Chapter 1—Materials and manufacturing methods. Chapter 2—Apparatus for making and breaking electric circuits. Chapter 3—Apparatus for preventing dangerous currents. Chapter 4—Apparatus for regulating amount of current. Chapter 5—Apparatus for starting and controlling electrical running machinery. Chapter 6—Low and medium tension switchboards. Chapter 7—High-tension and extra high-tension switchboards. Chapter 8—Apparatus for protection against abnormal conditions.

The classification under each one of these chapter headings is unusually complete, Chapter 1 starting out with specifications of raw material used in switch gear manufacture, discussing the methods of fabrication and finally methods of testing. A similar attention to detail is maintained in all the other chapters in the book.

The main objects of the book are to classify electric switch and controlling gear and to state the principles underlying its design. In this respect it is unfortunate for American engineers that most of the equipment described is of European design, for the American engineer is not likely to be very familiar with such equipment. However, no attempt has been made to describe all the products of the different manufacturers and the descriptions given in the text may be considered simply as representative examples or to illustrate some general principle. If the American readers keep this point in mind the European atmosphere of the equipment should result in no particular confusion.

Mathematics is used but this has been kept as simple as possible and all the calculations presented have been thoroughly tested in practical work.

The first edition of this book appeared in 1916 but since that time considerable progress has been made in the detailed standardization of switch gear and in this third edition this standardization has been fully recorded. It has also been considerably revised to correspond with the rapid developments which are continually taking place in this branch of electrical engineering.

STEPHENS-ADAMSON MFG CO., Aurora, Ill., has just issued a four-page folder describing its new JFS variable speed transmission.

AMERICAN BLOWER CO., 6000 Russell St., Detroit, Michigan, in an eight-page, well-illustrated booklet, describes the Venturafin Number 2 unit heater for building service.

CENTRIFUGAL PUMP USERS' GUIDE for July, 1927, issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis., lists a number of motor-driven centrifugal pumping units available for prompt shipment.

THE L. J. WING MFG. CO., 352 W. 13th St., New York City, has just published a new bulletin, No. 46, describing its motor-driven, variable-speed, forced-draft blower, designed for furnaces burning buckwheat coal.

JEFFREY MFG. CO., Columbus, Ohio, has just issued bulletin No. 435, describing and illustrating the Jeffrey Standard Apron Conveyors in wood and steel types for general conveying service. Applications of these conveyors to handling coal and other bulk materials are shown, with tables of dimensions and capacities of various types.

DRUM CONTROLLERS for two or three-phase slip-ring induction motors are described in bulletin CR3202 issued by General Electric Co., Schenectady, N. Y. Bulletin GEA-894 describes Automatic Switching Equipment for outdoor a-c reclosing feeder service, 440 to 73,000 v. Leaflet No. GEA-708 describes Solenoid-operated Air Circuit Breakers. Bulletin GEA-582 describes Automatic Switching Equipment for synchronous motor generators in lighting service.

ROBERT W. ADAMS, 1012 Turks Head Building, Providence, R. I., in a recent leaflet describes the Adams Transmission Line Calculator designed to solve transmission or distribution line problems, in the range of its scales, within two minutes.

ENGBERG'S ELECTRIC & MECHANICAL WORKS, 271 Vine St., St. Joseph, Michigan, has just issued a bulletin illustrating various applications of Engberg's engines to the driving of generators, fans, blowers, stokers and miscellaneous mechanical equipment.

WORTHINGTON PUMP AND MACHINERY CORP., 115 Broadway, New York, N. Y., in bulletin No. W-821 describes a trip through the Worthington Meter Factory.

LINK-BELT CO., 310 S. Michigan Ave., Chicago, Ill., has issued bulletin B-10 describing Link-Belt "All Purpose" Crawler, Shovels, Draglines and Cranes.

GENERAL ELECTRIC CO., Schenectady, N. Y., in an illustrated 56-page booklet, describes and illustrates motor drives for rolling mills.

GENERAL GAS & ELECTRIC CORP. has just issued a 36-page illustrated booklet reviewing the operations of its properties and featuring prominently the use of powdered coal in some of its power stations, especially the Middletown station.

CLIMAX ENGINEERING CO., Clinton, Iowa, has issued a series of letter sized booklets averaging 40 pages each, containing parts, price lists and operation instruction for their models R6U, R4U and TU engines and power units.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

He Thanked His Machine

Accepting the plaudits of the civilized world, the young man who flew the ocean included his instruments, his engine, his mechanical equipment in the homage paid him.

Lindy's "we" for the first time brought to the attention of the multitude of non-mechanical people the feeling that every really great builder and operator of machinery has for the machines which he creates and of which he is the master.

Even the ancient Greeks in their dramas had their "god in the machine," an actor in a contraption that was let down onto the stage in order that he might set to rights the tangled maze that had been depicted by the players.

Gods in the machines of today, the men who create mechanical power behind the scenes of our onward sweeping civilization, think, live and work with their equipment which gives light, heat and power, swift travel, marvelous buildings and ready communication to the whole race of men.

Whether with ears attuned to the hum of mighty new turbines or petting and coaxing along ancient engines and boilers, engineers in power plants give their lives to their machines and thank such staunchness as they find in them that service has not failed.

Farther back of the firing line, in laboratories, drafting rooms, foundries and shops, other armies of men give of their brain and brawn to create better metals, to perfect designs, to construct and build; perhaps to test out, lose out and build over again; that even more perfect machines, instruments and equipment may be available.

These men also serve, ofttimes supremely, always modestly, and their work, devices and creations live with them. Each man works with his own mechanical loves that become with himself the personified "we."

Overnight the devotion of the men who are masters of mechanical power was brought to the consciousness of all the people. A universal realization of the permanence and importance of power to every man's life and fortune was borne in upon us all. A higher regard was established for the men who are responsible for the continuity and economy of power generation.

Today the man in the street knows much about what power means to him. Today the mass of the people understand that efficient and economical power is essential to sound industrial development and a dominant factor in the investment value of industrial securities.

Alert power plant men now realize that their ideas will secure recognition to an extent never before possible.

Now is the time to marshal the facts regarding your power plants. Thousands of engineers have stated the case of their plant requirements, obtained the new equipment, the better supplies they knew were needed and demonstrated that these things paid handsome dividends on their cost.

Many such men have told the stories of such achievements directly to the readers of this publication or through its editors. Results of changing and rebuilding plants in dozens of great industries have been published here in the past few years.

To be most helpful to its readers in their service to their plants and to their consequent personal advancement, the September 15th number of this publication will be devoted to practical means of reducing industrial plant operating costs.

In this number the engineering features and equipment of a new ice plant will be described.

Overhauling of prime movers and condensers, of piping systems, and of electrical equipment will be considered in distinctive articles, each by a recognized authority. These articles will epitomize the first-hand experiences of the successful engineers in charge of industrial plants of companies known throughout the country.

A thorough discussion of power for the middle-sized plant by an author of wide experience should prove helpful to engineers in power plants of mills, factories, hotels and buildings of every kind.

Refuse fuel and pulverized fuel burning will also be discussed in this issue.

This Industrial Power Plant Number, the regular September 15th issue, will also contain the advertising of leading manufacturers of power plant machinery, equipment and supplies that have proved their service under many of the widely varying conditions that obtain in the power plants of leading industries.

All this additional editorial value is given without extra charge. If extra copies of this Specialized Number are desired for ready reference or for distribution to other departments, please place your orders now, as it is not likely that extra copies will be available after printing begins, on September 1st.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem, Pa.
Binks Spray Equip. Co., Chicago.
De Laval Steam Turbine Co., Trenton, N. J.
Gardner Governor Co., The, Quincy, Ill.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa
Sullivan Machy. Co., Chicago.
Worthington Pump & Mach. Corp., New York.
Yeomans Bros. Co., Chicago.

AIR COOLERS.
Sprav Engineering Co., Boston.

AIR FILTERS
Spray Engineering Co., Boston.

AIR PREHEATERS.
Air Preheater Corp., New York.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., New York, N. Y.
Power Specialty Co., New York.

AIR WASHERS
Buffalo Forge Co., Buffalo, N. Y.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland.
Wright-Austin Co., Detroit.

ANTI-CORROSIVE COATINGS
Dampney Co. of Am., Boston.

ARCHES, BOILER AND COMBUSTION
Brady Conveyors Corp., Chicago.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Detrick Co., M. H., Chicago.
Girtanner Engrg. Corp., N. Y.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Hofft Co., M. A., Indianapolis.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

ASH BIN GATES AND DOORS
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Conveyors Corp. of Am., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Combustion Engrg. Corp., New York, N. Y.
Conveyors Corp. of Am., Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Girtanner Engrg. Corp., N. Y.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

ASH TANKS
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Am., Chicago.

BABBITT METAL
Magnolia Metal Co., New York.

BAROMETERS
Taylor Inst. Co.'s, Rochester, N. Y.

BEARING METAL
Magnolia Metal Co., New York.

BEARINGS
National Tube Co., Pittsburgh.

BELT CONVEYORS
Jeffrey Mfg. Co., Columbus.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELTING
Crandall Pkg., Palmyra, N. Y.
Quaker City Rubber Co., Phila.

BELTING, SILENT CHAIN
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE
Air-Preheater Corp., New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, PRESSURE
Carling Turbine Blower Co., Worcester, Mass.

BLOWERS, PULVERIZED COAL
Buffalo Forge Co., Buffalo.

BLOWERS, STEAM
Schutte & Koerting Co., Phila.

BLOWERS, TUBE
Diamond Power Spec. Corp., Detroit, Mich.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.

BOILER SETTINGS
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N.Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Rust Engrg. Co., Pittsburgh.
Walsh & Weidner Boiler Co., Chattanooga, Tenn.
Walsh Fire Clay Products Co., St. Louis, Mo.

BOILER TUBE CLEANERS
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.

BOILER TUBES
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS
Botfield Refractories Co., Phila.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 162

BLOWERS, TURBINE
Carling Turbine Blower Co., Worcester, Mass.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES
Boiler Engrg. Co., Newark, N. J.
Engineer Co., The, New York.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., N. Y.

BOILER CAP CLEANERS
Lagonda Mfg. Co., Springfield, O.

BOILER CASING
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.

BOILER COATINGS
Dampney Co. of Am., Boston.

BOILER COMPOUND
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N.Y.
Paige & Jones Chem. Co., Inc., New York.

BOILER COMPOUND FEEDERS
Hills-McCanna Co., Chicago, Ill.

BOILER ENGINEERS
Boiler Engrg. Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., Inc., New York.
Permutit Co., New York, N. Y.

BOILER FRONTS
McLeod & Henry Co., Troy, N.Y.

BOILER MOUNTINGS
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
Insulating Products Corp., N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.
Insulating Products Corp., N. Y.

BOILERS
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Combustion Engrg. Corp., New York, N. Y.
Connelly Boiler Co., The D., Cleveland, O.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie.
Heine Boiler Co., St. Louis, Mo.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Ladd Water Tube Boiler Co., Pittsburgh, Pa.
Murray Iron Works Co., Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee.
Walsh & Weidner Boiler Co., The, Chattanooga, Tenn.
Wickes Boiler Co., Saginaw.

BRICKS, FURNACE LINING
Norton Co., Worcester, Mass.

BREECHINGS
Connery & Co., Inc., Phila.
Heine Boiler Co., St. Louis, Mo.
Littleford Bros., Cincinnati.

BRUSHES, DYNAMO AND MOTOR
Calebaugh Self-Lubricating Carbon Co., Inc., Philadelphia.
Dixon Crucible Co., Jos., Jersey City, N. J.
LeValley Vitae Carbon Brush Co., New York, N. Y.

BRUSHES, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS
Brady Conveyors Corp., Chicago.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, COAL HANDLING
Jeffrey Mfg. Co., Columbus, O.

CAR DUMPERS
Wellman-Seaver-Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET
Jeffrey Mfg. Co., Columbus, O.
Webster Mfg. Co., The, Chicago.

CASTINGS
Erie City Iron Wks., Erie.
Fuller Lehigh Co., Fullerton, Pa.
Girtanner Engrg. Corp., N. Y.
Hills-McCanna Co., Chicago.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, FURNACE
Botfield Refractories Co., Phila.
Carborundum Co., Perth Amboy.
Denver Fire Clay Co., Denver.
Harbison-Walker Refract. Co., Pittsburgh.
Insulating Products Corp., N. Y.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refract. Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., Inc., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT, HIGH TEMPERATURE
Botfield Refractories Co., Phila.
Denver Fire Clay Co., Denver.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Johns-Manville Corp., New York.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., N. Y.
Walsh Fire Clay Products Co., St. Louis, Mo.

CEMENT, INSULATING
Insulating Products Corp., N. Y.

CEMENT, IRON
Smooth-On Mfg. Co., Jersey City.

CHAIN WHEELS
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHEMICALS, WATER TREATING.
Chicago Chemical Co., Chicago.
Permutit Co., New York.

CHIMNEYS
American Chimney Corp., N. Y.
Rust Engrg. Co., Pittsburgh.
Springfield Boiler Co., Springfield, Ill.

CIRCUIT BREAKERS
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE
General Spec. Co., Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CLEANING COMPOUND
Dearborn Chem. Co., Chicago.

COAL AND ASH-HANDLING MACHINERY
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Am., Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

COAL BUNKERS, CAST IRON, CATENARY
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.

COAL CRUSHERS
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., Columbus, O.
Pennsylvania Crusher Co., Phila.
Stephens-Adamson Mfg. Co., Aurora, Ill
Webster Mfg. Co., The, Chicago.
Williams Patent Crusher & Pulverizer Co., St. Louis, Mo.

COAL STORAGE EQUIPMENT
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Am., Chicago.